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NIE 11-2-59
16 JUNE 1959
TS 117450

NATIONAL INTELLIGENCE ESTIMATE NUMBER 11-2-59

THE SOVIET ATOMIC ENERGY PROGRAM

LIMITED DISTRIBUTION

Submitted by the
DIRECTOR OF CENTRAL INTELLIGENCE

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Concurred in by the
UNITED STATES INTELLIGENCE BOARD

on 16 June 1959. Concurring were The Director of Intelligence and Research, Department of State; the Assistant Chief of Staff for Intelligence, Department of the Army; the Assistant Chief of Naval Operations for Intelligence, Department of the Navy; the Assistant Chief of Staff, Intelligence, USAF; the Director for Intelligence, The Joint Staff; the Assistant to the Secretary of Defense, Special Operations; the Atomic Energy Commission Representative to the USIB; and the Director of the National Security Agency. The Assistant Director, Federal Bureau of Investigation, abstained, the subject being outside of the jurisdiction of his Agency.

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NATIONAL INTELLIGENCE ESTIMATE

THE SOVIET ATOMIC ENERGY PROGRAM

NIE 11-2-59

16 June 1959

This estimate supersedes NIE 11–2–58, 14 January 1958, the Supplement to NIE 11–2–58, 30 September 1958 and Annex C to NIE 11–5–58, 19 August 1958.

This estimate was prepared and agreed upon by the Joint Atomic Energy Intelligence Committee, which is composed of representatives of the Departments of State, Army, Navy, Air Force, the Atomic Energy Commission, The Joint Staff, the National Security Agency, the Assistant to the Secretary of Defense, Special Operations, and the Central Intelligence Agency. See appropriate footnotes, however, for the dissenting views of the Army, Navy, Air Force, The Joint Staff and the Assistant to the Secretary of Defense, Special Operations. The FBI abstained, the subject being outside of its jurisdiction.

A group of expert consultants working with the Joint Atomic Energy Intelligence Committee has reviewed this estimate and generally concurs with it. The estimate, with footnotes, was approved by the United States Intelligence Board on 16 June 1959.

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THE SOVIET ATOMIC ENERGY PROGRAM

THE PROBLEM

To estimate the current status and probable future course of the Soviet atomic energy program to mid-1964.[a]

SUMMARY AND CONCLUSIONS

GENERAL

1. In contrast with Khrushchev's repeated statements of nuclear sufficiency, there is substantial evidence that the USSR is continuing a high priority expansion of its atomic energy program. Although the atomic energy effort remains oriented primarily toward military applications, emphasis on non-military uses has continued to increase since the formation in 1956 of the Chief Directorate for the Utilization of Atomic Energy. However, centralized control of nearly all aspects of the program has been maintained under the Ministry of Medium Machine Building, one of three industrial ministries which were allowed to retain all-union status in spite of the general Soviet program for decentralization of industrial control.

[a] The reference to a five year period is approximate. For example, we have presented rough figures on the cumulative production of fissionable materials through mid-1969 in order to provide a general indication of what levels of production may be attained. Weapons estimates, on the other hand, extend only to mid-1963.

TECHNICAL CAPABILITIES

2. The emphasis on nuclear technology in the Soviet Union has continued during the past year with steady pressure on nearly all scientific frontiers. Advances have stemmed both from the USSR's own efforts and from prompt and extensive exploitation of open Western scientific work. Nevertheless, it is estimated that Soviet basic research in nuclear technology, while highly competent in specific fields, is not comparable in diversity and scope to that of the US.

PROPULSION REACTORS

Naval and Marine Applications

3. The first Soviet nuclear powered surface ship, the icebreaker LENIN, will be put into operation during the latter half of 1959. Based on the status of reactor technology evidenced in the LENIN and at nuclear electric power plants, the prototype of a submarine propulsion reactor could have been available late in 1957. Although no firm evidence of the existence of Soviet nuclear submarines has

been obtained to date, we estimate that one or possibly as many as three nuclear powered submarines could have gone into operation by the end of 1958, and that by mid-1963 the Soviets could have about 25 nuclear powered submarines.

Aircraft Nuclear Propulsion

4. Although we have no firm evidence, we estimate that the USSR has been engaged in the development and testing of aircraft nuclear propulsion (ANP) components and sub-systems for some time. We believe that at any time the USSR could fly a nuclear testbed with at least one nuclear power unit providing useful thrust during some phase of the flight. A prototype reactor system suitable for subsonic cruise propulsion on nuclear heat alone could become available by 1962, but it would be 1964 before reliable reactor systems could begin to become available for operational use.[1] Supersonic applications of ANP would require a long test and development program, and we estimate that a prototype will not be achieved until after 1964.

NUCLEAR ELECTRIC POWER REACTORS

5. The USSR is exploring the advantages of various types of power reactors in an effort to obtain competitive nuclear power and is constructing several large plants. It is also certain that they will fail by at least two years to reach the objectives laid down in 1956 in their sixth five-year plan. However, they have made considerable progress, and it is estimated that they will have 2,000 electrical megawatts (EMW) of installed nuclear generating capacity by 1963.

CONTROLLED THERMONUCLEAR REACTIONS

6. Soviet research on controlled thermonuclear reactions appears to have begun in the 1950–1951 period, and the present scope of its program is comparable to and almost on a par with that of the US and UK. This program could be successful in achieving a controlled thermonuclear reaction as soon as any other group in the world, but the production of useful energy cannot be expected for a long time.

FISSIONABLE MATERIALS PRODUCTION

Uranium Ore

7. The availability of substantial uranium ore reserves within the Soviet Bloc and particularly the USSR indicates that the amount of uranium ore production is limited only by the investment the Soviets wish to make in the program and not by a scarcity of exploitable ore deposits. The exploitation of these resources is being steadily expanded. We estimate that approximately 15,400 metric tons of recoverable uranium will be mined during 1959, of which about 6,400 metric tons will come from the USSR and about 9,000 metric tons from the Satellites. These amounts are in excess of that required to support the current estimates of fissionable materials production.

Uranium-235

8. We have firm evidence that there are gaseous diffusion plants at Verkhney-vinsk and Tomsk which have been in

[1] The Assistant Chief of Staff, Intelligence, USAF; the Director for Intelligence, Joint Staff; and the Assistant to the Secretary of Defense for Special Operations do not agree with the first three sentences of paragraph 4, above, and believe instead that the USSR has been engaged in the high priority development and testing of reactor components and sub-systems for some time, and that a reactor system suitable for nuclear propulsion of subsonic aircraft could be available to the Soviets in 1962.

operation since the early 1950's. A third plant, near Angarsk, may have gone into operation during the first half of 1958. There is evidence of continuing expansion of the capacities of these three facilities.

9. We estimate that the Soviets will have produced the equivalent of 45,000 kg. of weapons grade [2] U–235 by mid-1959 and that this cumulative amount will have increased to about 225,000 kg. by mid-1964. Figure 1 on page 4 presents the estimated cumulative production at each mid-year up to 1964. The actual production up to 1961 could range within ±50% of the stated values, with even greater uncertainties after that year.[3]

Plutonium Equivalent [4]

10. During the 1948–1955 period, the USSR put plutonium production reactors into operation at sites located in the vicinity of Kyshtym, Tomsk, and probably Krasnoyarsk. We have evidence of continuing expansion at these sites.

11. We estimate that the Soviet cumulative production of plutonium equivalent will have reached a total of about 12,000 kg. by mid-1959. This amount will probably have increased to something in the order of 37,000 kg. by mid-1964. Figure 1 on page 4 presents the estimated cumulative production at each mid-year up to 1964. The actual production up to 1961 could range from one-third to twice the stated values, with even greater uncertainties present after that year.[5] We estimate that as much as 10% of the total plutonium equivalent produced would be in the form of tritium up to mid-1959, with this percentage increasing after that date.[6]

12. The Soviets probably had strong economic incentives to process fully all available ore. However, if this course were followed and our U–235 estimate is approximately correct, the actual production of plutonium equivalent would be substantially greater than the most prob-

[2] 93% enriched.

[3] In order to accept the estimate of cumulative production of U–235 (Figure 1) the Assistant Chief of Naval Operations for Intelligence, Department of the Navy, finds that he would have to accept major factors of Soviet capability since 1953 which are in his opinion not sufficiently supported by available evidence. These factors include: (a) initial operation dates of new plants, (b) degree of enrichment and depletion of materials produced, (c) use of a new diffusion technology and new equipment, and (d) over-all plant efficiency. However, he believes that the assumption that an improved technology and improved plant efficiency have been developed and incorporated in new plants installed during 1953–1959 is consistent with known Soviet technological capabilities. The Assistant Chief of Naval Operations for Intelligence, Department of the Navy, believes that the lower limits of the estimated values for the cumulative production of U–235 are the more nearly correct.

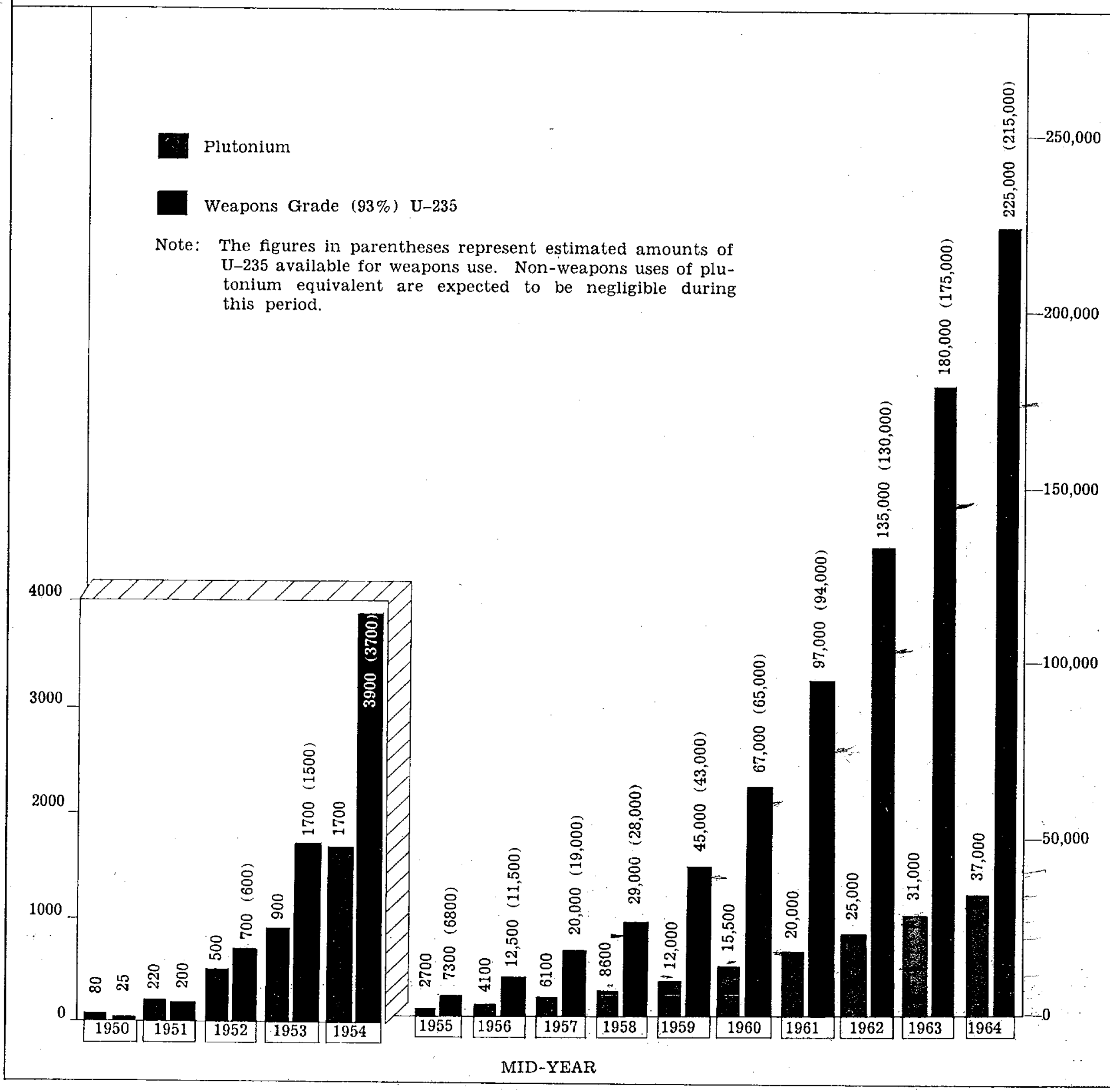
[4] The production of plutonium and all other reactor-produced isotopes is of necessity estimated collectively in terms of equivalent quantities of plutonium.

[5] [redacted] In view of the above and the uncertainty of information as to the possible form and size of stockpiled uranium, as well as the uncertainty of information as to the input of uranium metal into production reactor operation, the Assistant Chief of Naval Operations for Intelligence, Department of the Navy, believes that the lower limit of the estimate, [redacted] represents the most probable value for plutonium production.

[6] For planning purposes 10 grams of tritium is considered equal to one kilogram of plutonium.

ESTIMATED CUMULATIVE PRODUCTION (IN KILOGRAMS) OF FISSIONABLE MATERIALS[7]

(See paragraphs 9 and 11 for the range of uncertainties of these values)



[7] See Footnotes 3 and 5, page 3, for the position of the Assistant Chief of Naval Operations for Intelligence, Department of the Navy.

FIGURE 1

able values indicated above. On the other hand, [redacted] a reliable minimum estimate [redacted] amounts to about one-third of the stated values.

13. Our estimates of the Soviet fissionable material production made in NIE 11–2–58 have not materially altered, but additional information obtained over the past year has increased our confidence in the estimated Soviet production of U–235 up to 1961.

NUCLEAR WEAPONS

Test Program

14. The Soviet nuclear weapon development program has grown rapidly, achieved great progress in weapons design, and included the test of a varied assortment of devices from which Soviet military planners can draw in meeting their requirements. Soviet tests have been conducted with yields ranging from approximately 1 kiloton (KT) to nearly 8 megatons (MT). [redacted]

15. Thirty-one of the 74 Soviet nuclear tests [redacted] were conducted during 1958. This effort represented a marked acceleration in their test program and was probably designed to exploit, in the face of a possible test ban, the several avenues of investigation which emerged from previous test series. We have evidence indicating that some relatively low-yield tests were conducted by the USSR [redacted]

16. Preliminary analyses of the thirty-one Soviet tests conducted during 1958 indicate that a concerted development effort continued on [redacted] thermonuclear (TN) devices. Yields approaching 8 MT were achieved, [redacted] The Soviets further developed economical low-yield (less than 10 KT) weapons possibly for air defense or tactical use.

Nuclear Weapons Capabilities

17. No direct information is available on the specific nuclear weapons types in the USSR stockpile. The estimate of Soviet nuclear weapons development potential shown in Tables 1 and 2 has been based on data acquired in connection with the 74 known Soviet tests, and by using US weapons technology as a guide. Some of the weapon designs listed have been de-

Table 1

ESTIMATED SOVIET THERMONUCLEAR WEAPON DEVELOPMENT POTENTIAL

(Based on estimated current Soviet capabilities, using US developments as a guide)
(Potential improvements indicated for the 1961–63 period are based on unlimited testing)

Number	Approx. Diam. (in)	Approx. Weight Class (lbs) (Reasonably attainable minimum weights) Bomb Class	Approx. Amounts of Nuclear Materials U–235	Approx. Yield (MT) 1957–58	1959	1960	1961	1962	1963
TN–1	35	12,000							
TN–2 [b]	50	[b] 11,000							
TN–3A [c]	35	6,500							
TN–3B	..	..							
TN–3C	..	..							
TN–4A [c]	35	5,500							
TN–4B [c]	..	..							
TN–5A	30	5,500							
TN–5B	..	..							
TN–5C	..	..							
TN–6A [c]	30	4,500							
TN–6B	..	..							
TN–6C	..	..							
TN–7A	30	3,500							
TN–7B	..	..							
TN–8A [c]	24	2,500							
TN–8B [c]	..	..							
TN–8C	..	..							
TN–9A [c]	22	2,000							
TN–9B	..	..							
TN–9C	..	..							
TN–10A [c]	18	1,300							
TN–10B	..	..							

[a] Includes fuzing and firing system, but not ballistic case or nose cone.

[b] These weapons would require at least one test in either full-scale or reduced-yield configurations before stockpiling on other than an emergency basis.

[c] Based on analysis of specific Soviet tests.

[d] Based on Soviet tests conducted in 1958 and would not be available in stockpile in 1959 except in limited quantities (10 to 50 weapons).

Table 2

ESTIMATED SOVIET FISSION WEAPON DEVELOPMENT POTENTIAL

(Based on estimated current Soviet capabilities, using US developments as a guide)
(See footnote [b] *re* estimated future fission weapons development capabilities)

Number	Approx. Diam. (in)	Approx. Weight Class (lbs) (Reasonably attainable minimum weights) Bomb Class	Approx. Amounts of Nuclear Materials U-235	Approx. Yield (KT) 1957–58	1959	1960–63
[redacted]			[redacted]	[redacted]	[redacted]	[redacted]
F-1	18	350				
[redacted]						
F-2A [c]	45	3, 500				
F-2B [c]	..	..				
F-3A [c]	30	1, 200				
F-3B [c]	..	..				
F-4 [c]	25	1, 000				
F-5A [c]	20	700				
F-5B [c]	..	..				
F-5C [c]	..	..				
F-6 [c]	20	450				
F-7A [c]	18	300				
F-7B	..	..				
F-7C	..	..				
F-7D [c]	..	..				
F-7E [c]	..	..				
F-7F	..	..				
F-8 [c]	16	350				
[redacted]						
F-9	10	450				
F-10A	8	250				
F-10B	..	..				

[a] Includes fuzing and firing system, but not ballistic case or nose cone.

[b] Assuming continued testing, we believe only slight improvement will be made in these weapon categories and we estimate that the above 1959 Soviet fission weapons development potential adequately reflects their capabilities for the period 1959–1963. See paragraphs 179 and 181 in text for discussion of extremely light-weight devices and gun-assembly weapons.

[c] Based on analysis of specific Soviet tests.

[d] Based on Soviet tests conducted in 1958 and would not be available in stockpile in 1959 except in limited quantities (50 to 100 weapons).

rived from analysis of specific tests. Others represent projections of demonstrated techniques and the estimated status of Soviet nuclear weapons technology.

[redacted]

18. In Tables 1 and 2, we estimate that during 1959 the Soviets have the capability to produce thermonuclear missile warheads with weights and yields from 1,000 pounds [redacted] to 6,000 pounds [redacted] These same devices could be used in bombs if additional weight is allowed for the bomb casing. The Soviets could also have available in 1959 fission weapons with yields of from one to about 100 KT with a variety of weights and dimensions. If no further nuclear testing occurred, these capabilities could only be marginally improved. However, with continued unlimited testing the Soviets could improve the fissionable material economy of these weapons, increase the maximum yield, and develop still further weapons to satisfy a wide variety of military requirements.

19. In the post-1963 period, we do not expect the advancement of Soviet nuclear weapon development to be as rapid as in the past, since we believe that they have reached a state of the art where major improvements in performance are difficult to achieve.

20. Although no major changes have been made in the Soviet weapons development capabilities from those estimated in NIE 11–2–58, analyses of the Soviet tests in 1958 indicate that [redacted]

Nuclear Weapons Stockpiling

21. We believe that extensive long-range plans for a dispersed assembly and storage system were under way at least as early as 1952. The development and implementation of these long-range plans have been closely integrated with the growth of Soviet nuclear weapon production capacity, and the design and construction of the physical facilities have paralleled specific requirements emerging from developing nuclear weapon designs.

22. We believe that at least three national assembly and stockpile sites were built by, and possibly are operated by, the Ministry of Medium Machine Building. [redacted] They are believed to be the central part of the Soviet nuclear weapons logistics system and are designed to supply weapons for all types of military nuclear delivery systems. [redacted]

23. Our knowledge of the location and nature of storage facilities available to the military is confined principally to two types of operational storage sites located at airfields of Long Range Aviation. We estimate that, in addition to these sites,

facilities for nuclear weapons storage exist at several naval airfields and airfields of the Tactical Aviation. Although no nuclear weapon storage facilities have been identified at naval surface facilities or co-located with ground force units, we believe that appropriate storage facilities for them probably exist.

ALLOCATION OF FISSIONABLE MATERIALS[10, 11]

24. We have insufficient evidence to support a firm estimate of the Soviet weapons stockpiles by number, by type, by mission, or otherwise. Accordingly, in making such an estimate we are forced to rely on our general assessments of over-all Soviet military policy and strategy and on our estimates of the types of weapon systems and missions which might employ nuclear weapons wholly or in part.

25. To derive illustrative weapon allocations, we have combined our specific estimates of Soviet development and production of nuclear weapon delivery systems, studies of probable targets for nuclear weapon systems, the estimated production of fissionable materials, and intelligence information on stockpiling practices and doctrine for the use of nuclear weapons. All of the above factors are subject to appreciable margins of error.

26. By varying the number of high-yield weapons allocated to the Long-Range Aviation (LRA) we have arrived at two alternative allocations. Alternative A entails greater emphasis on weapons for support of ground forces and air defense, and Alternative B places dominant emphasis on long range strike forces. In mid-1959, the total number of weapons is about 3,000. For Alternative A there would be approximately 800 high-yield weapons for the LRA and for missiles capable of employment against the US. For Alternative B, there would be approximately 1,200 high-yield weapons for these uses. In mid-1962, the number of weapons varies from a total of about 9,000 for Alternative A with approximately 2,300 high-yield weapons for the LRA and for missiles capable of employment against the US, to a total of about 7,000 for Alternative B with approximately 2,700 high-yield weapons for these uses. Considering the estimated availability of fissionable materials and the level of Soviet nuclear weapons technology, we believe that at present the USSR probably possesses sufficient nuclear weapons to support a major attack by its long range striking forces, including sufficient nuclear warheads for all of its operational submarine launched missiles and ground launched ballistic missiles of 700 n.m. range and greater. At present the quantity of fissionable material will limit the

[10] The Assistant Chief of Naval Operations for Intelligence, Department of the Navy, believes that the range of possible Soviet quantitative allocations to weapons stockpiles is so broad that, in view of the status of available intelligence on this subject (as indicated in paragraph 24), an estimate of "possible allocations" is unrealistic and of doubtful usefulness. Therefore, he does not concur with the general methodology employed to derive this section or with the illustrative allocations (paragraph 26).

[11] The Assistant Chief of Staff for Intelligence, Department of the Army, does not concur with the methodology employed to derive this section or with the "illustrative allocations" (paragraph 26). In view of the insufficiency of evidence on this subject (as indicated in paragraph 24), he considers that the "illustrative allocations" are merely highly speculative possibilities selected arbitrarily from an almost infinite number of alternative choices. At best such theorizing from unsupported conjecture is unrealistic and of doubtful value; it creates a high risk of inadvertent misuse, for example, in briefings for budgetary or planning purposes, leading to the danger of miscalculation by those responsible for national security.

number of nuclear weapons available for air defense and tactical uses. This shortage will be considerably alleviated by 1962.

INTERNATIONAL ATOMIC AID AND EXCHANGE PROGRAM

27. The Soviet Union apparently has two objectives behind her offers of material and technical aid to other nations throughout the world. The Soviets have used their aid and exchange program to improve and tighten their relationship with Bloc nations while maintaining a substantial degree of control over the atomic energy activities in these countries. In the offers to the Free World nations, the objective has been largely one of propaganda.

28. There is little doubt that the Soviet Union has the technical capability to fulfill the offers of aid that have been made. Promises of equipment, radioisotopes, and basic technical training to the Satellites have been largely fulfilled. Offers to the non-Bloc countries, however, have been largely on a bi-lateral basis, and neither Egypt nor Yugoslavia has a reactor in operation at present. Soviet participation in exchange conferences with the free world appears to be slanted toward propaganda purposes and collection of technical information on western atomic energy developments.

ECONOMIC ASPECTS OF THE SOVIET ATOMIC ENERGY PROGRAM [12]

29. We estimate that the approximate cumulative cost of the Soviet nuclear program through mid-1959 has been over 90 billion rubles including about 40 billion for plant and equipment and about 50 billion for operating expenses. Total expenditures have been less than 1% of Soviet gross national product in recent years. In monetary terms, Soviet investment in plant and equipment for fissionable materials production has been about 75% of that of the US, but because of estimated low process efficiencies the estimated Soviet plant capacities are relatively very much smaller. These and other cost estimates must be considered as first approximations and are subject to wide margins of error; however, it is felt that they adequately reflect general magnitudes and relations.

[12] The Assistant Chief of Naval Operations for Intelligence, Department of the Navy, does not concur in the economic section because it is based upon a method of cost analysis that he does not consider can be applied to the USSR fissionable materials estimate.

DISCUSSION

I. INTRODUCTION

30. The general nature and some of the details of the Soviet atomic energy program can be assessed with reasonable reliability. There can be no doubt that the USSR is continuing to expand its extensive atomic energy program on a high priority basis and to direct it primarily toward military applications.

31. Available information still does not permit precise estimates of Soviet fissionable material production. However, additional information has been obtained over the past year which increases our confidence in the estimated Soviet production of U–235 up to 1961.

32. Technical methods of collection continued to provide high quality coverage of the Soviet nuclear weapons test program. We have also achieved more understanding of Soviet weapon stockpiling practices from reliable information received during the past year.

II. ORGANIZATION OF THE SOVIET ATOMIC ENERGY PROGRAM

33. Prior to June 1953, the operation of the Soviet atomic energy program was the concern of two chief directorates attached to the Council of Ministers. The First Chief Directorate concerned itself with fissionable materials production and with nuclear weapon development and production. The Second Chief Directorate was responsible for raw materials, including the development of new uranium deposits, mining, and ore concentration and refining, both inside and outside the USSR. A third Chief Directorate, GLAVGORSTROY, which was also attached to the Council of Ministers, provided supply and administrative service for both the First and Second Chief Directorates. L. P. Beriya was the responsible Deputy Chairman of the Council of Ministers and exercised over-all direction of the development of the Soviet atomic energy program.

34. After the arrest of Beriya in June 1953, the Ministry of Medium Machine Building was created with V. A. Malyshev as the minister. The new ministry gradually assumed all the functions of the three chief directorates and over-all control and direction of the Soviet atomic energy effort.

35. The formation of a separate "peaceful uses" atomic energy coordinating body, the Chief Directorate for the Utilization of Atomic Energy attached to the Council of Ministers, to be headed by Yefim P. Slavskiy, was announced by TASS in April 1956. Slavskiy retained this position until his appointment as Minister of Medium Machine Building in July 1957. In September 1957, the USSR announced the appointment of Dr. Vasiliy S. Yemel'yanov to replace Slavskiy as Chief of the Chief Directorate. Yemel'yanov, who has been Director of Research for the atomic energy program, has headed the Soviet delegation to both Geneva Conferences on Peaceful Uses of Atomic Energy.

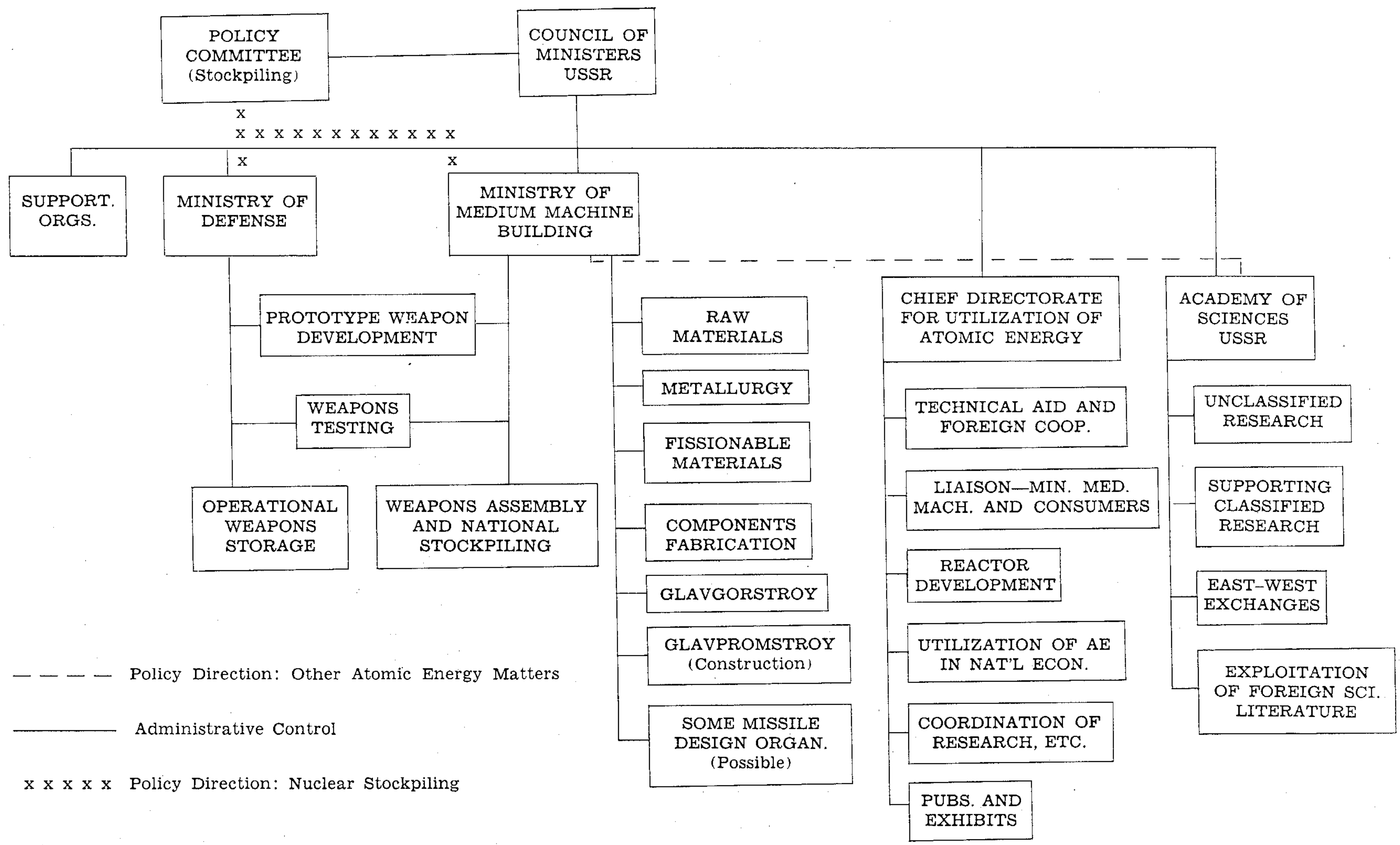
36. This Chief Directorate was created to fulfill several announced functions: to develop cooperation between the USSR and other countries in the non-military uses of atomic energy; to make extensive use of atomic energy in the national economy in cooperation with industry and to resolve problems connected with this application; to design reactors for power stations and to develop nuclear powered engines for use in transportation; to build and operate experimental reactors; to coordinate research in nuclear technology: e.g., the production and use of radioisotopes and the effect of radiation on metals; and to supply laboratories with experimental equipment such as counters, reactors, and accelerators. The Chief Directorate is also responsible for the publication of scientific and technical works on the utilization of atomic energy and for holding exhibits on peaceful uses of atomic energy both in the Soviet Union and in other countries.

37. The third major organization concerned with atomic energy in the USSR is the Academy of Sciences of the USSR. The role of the Academy of Sciences in the field of atomic energy has been changing since 1956. Originally, the Academy operated classified nuclear laboratories of the USSR which directly supported the programs of the Ministry of Medium Machine Building and its predecessor, the First Chief Directorate.

38. The Ministry of Medium Machine Building is responsible for all production aspects of the atomic energy program, the Chief Directorate for the Utilization of Atomic Energy supervises the application of non-military uses of atomic energy within the USSR and the cooperation of the USSR with other countries in these matters, and the Academy of Sciences is apparently used to advise and conduct supporting research for both the Ministry and the Chief Directorate. The major organizational relationships of the Soviet atomic energy program are presented in Table 3 on page 13.

TABLE 3

MAJOR ORGANIZATIONAL ELEMENTS OF THE SOVIET ATOMIC ENERGY PROGRAM



— — — — Policy Direction: Other Atomic Energy Matters

———— Administrative Control

x x x x x Policy Direction: Nuclear Stockpiling

39. Since 1956, the Ministry of Medium Machine Building has been gradually removing all classified work from several of the previously sensitive atomic energy laboratories; i.e., Dubna, Moscow Atomic Energy Institute, Moscow Thermotechnical Institute, Obninsk Reactor Research Center, Leningrad Technical Institute. The Academy of Sciences is apparently assuming more direct control over their activities, and it is apparent that the Academy now controls the following:

a. unclassified research which the USSR is willing to release in the fields of high energy physics and accelerators, controlled thermonuclear reactions, research reactors and reactor physics, and biology and medicine and radioisotopes; and

b. with respect to East-West scientific exchanges, Russian participation in Western activities and visits of Western scientists to the USSR.

40. Nuclear research and development laboratories and institutes appear to be grouped into several general areas according to the sensitivity of the work conducted therein and their organizational subordination or control. The USSR maintains that the Academy of Sciences controls all basic research in the USSR, operating the vast majority of the research institutes and laboratories. However, we believe that the Minister of Medium Machine Building controls at least the availability of nuclear fuels for peaceful uses and, through a strict security classification policy, nuclear research and technical aid.

41. Identification of the organizational relationships affecting the research, uranium mining, feed materials production, and fissionable materials production aspects of the Soviet atomic energy program has been based on relatively firm evidence. Organizational relationships affecting the nuclear weapon design, development, testing, and storage aspects of the program are less well defined.

42. Very little is known of the Soviet nuclear weapons and research laboratories at fissionable material production sites, either with regard to size, scope, manpower or past and present subordination. It is believed that these laboratories are under the direct control of and operated by the Ministry of Medium Machine Building. We believe that the principal Soviet weapons development center is located in the vicinity of Sarova (5456N–4320E). Subordination of this research center also is believed to have been to the First Chief Directorate until 1953 and to the Ministry of Medium Machine Building thereafter.

43. The nuclear weapons proving ground at Semipalatinsk and installations supporting the test area on Novaya Zemlya are probably under the operational control of the military. Test activity itself is probably a joint effort by both the military and the scientific laboratories involved, with the Ministry of Medium Machine Building exercising technical direction.

44. We believe that the Ministry of Medium Machine Building is responsible for the operation of national assembly and stockpile sites and that the individual services are responsible for the operational storage of nuclear weapons. We have no information as to which Soviet governmental element is responsible for the allocation of nuclear weapons from the national stockpile to the individual services. We believe, however, that this responsibility most likely rests with a committee composed of the highest ranking members of the Soviet government, who represent jointly the economic, political, and military interests of the Soviet state.

45. Recent evidence suggests that atomic energy has not been the sole concern of the Ministry of Medium Machine Building but that at least one Soviet missile design organization has also been subordinate to this ministry. Late in 1953 the Leningradskoye Shossee Institute (LSI), Moscow, was transferred to the Ministry of Medium Machine Building. LSI reportedly worked on guidance and control systems for air-to-air, air-to-surface, and surface-to-air missiles. However, the extent of the association between the Ministry of Medium Machine Building and the Soviet guided missile program remains unknown.

46. It is significant that the Ministry of Medium Machine Building is one of the three remaining all-union industrial ministries in the USSR. Since 1957, in conformance with Khrushchev's decentralization program, the all-union industrial ministries have been disbanded gradually and their functions transferred to regional economic councils. By retaining the Ministry of Medium Machine Building as an all-union ministry, the USSR continues to maintain a high degree of security and a strict, centralized control over at least all production phases of the atomic energy program. The organizational history of the Soviet atomic energy program is portrayed graphically in Table 4 on page 16.

TABLE 4

ORGANIZATIONAL HISTORY AND SELECTED FUNCTIONS OF THE PRIMARY AGENCIES OF THE SOVIET ATOMIC ENERGY PROGRAM

1940	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58

Commission on the Uranium Problem, Att. to Presidium of the Academy of Sciences—Basic Research

Ninth Directorate of the MVD

Basic and Applied Research Uranium Mining 1944–1945

First Chief Directorate Att. to the Council of Ministers

Gradually Assumed Programmatic Functions of Ninth Directorate Uranium Mining Relinquished in 1950

Glavgorstroy a Chief Directorate Att. to the Council of Ministers

Service Organization for First and Second Chief Directorates

Second Chief Directorate Att. to Council of Ministers

All uranium mining

Ministry of Medium Machine Building

Assumed all Functions, Except Satellite Uranium Mining, which it finally assumed in 1956

Chief Directorate of Soviet Property Abroad

Foreign Uranium Procurement

Chief Directorate for the Utilization of Atomic Energy Att. to Council of Ministers

Non-military activities

III. SOVIET TECHNICAL CAPABILITIES IN NUCLEAR ENERGY

INTRODUCTION

47. The emphasis on nuclear technology in the Soviet Union during the past year has continued with steady pressure on nearly all scientific frontiers. Advances in Soviet technology have stemmed both from the Soviets' own efforts and from prompt and extensive exploitation of open Western scientific work.

NUCLEAR PHYSICS

48. Significant advances in Soviet nuclear physics have been made during recent years. Among them are the 680 million electron-volt (Mev) synchrocyclotron and a 10 billion electron-volt (Bev) proton synchrotron which began limited operation in 1957 but has only recently attained designed proton beam intensity. In addition, the 7 Bev prototype for a 50 Bev proton synchrotron using strong focusing is nearing completion at the Thermotechnical Laboratory, Moscow. Also under construction at the present time is a cyclotron specifically designed for acceleration of heavy ions.

49. Various sources reveal that Soviet physicists have become competent in standard measurement techniques employed in nuclear spectroscopy. In addition, they have initiated their own refinements and innovations in this field. An intensive and competent Soviet effort appears to be directed toward the development of high-resolution time-of-flight neutron spectrometers. They are currently developing a pulsed reactor design to supply high flux bursts of neutrons in conjunction with time-of-flight neutron spectroscopy.

50. However, the obvious priority accorded by the Soviets to their high energy nuclear physics research has probably diverted effort from the less dramatic but equally important low energy research. In general, it is estimated that the Soviet Union still lags behind the US substantially in basic nuclear research and that the deficiency lies mainly in the quantity and diversity of the research being performed.

NUCLEAR CHEMISTRY

51. The Soviets' open literature demonstrates a high degree of technical competence in most fields of nuclear chemistry. Various Soviet publications indicate a widespread and rapidly growing use of radioisotopes in research and industry. The Soviets have studiously omitted any discussion in the open literature of uranium or heavy isotope separation.

52. In the last year and one-half the Soviets have started to publish on chemical separation methods, particularly on solvent extraction. It appears that chemical separations technology in the USSR is fairly well advanced, and that the Soviet Union apparently developed a workable solvent extraction system earlier than previously anticipated. A laboratory process described at the 1958 Geneva Conference on Peaceful Uses included, according to the Soviet paper, provisions for removal of radioactive materials, iodine, krypton, and xenon in order to facilitate the re-use of nitric acid solvent.

53. The Soviet work which was revealed in papers presented at the 1958 Geneva Conference on Peaceful Uses indicates that their research on ion exchange techniques and on separation and identification of transuranium compounds may be lagging behind similar efforts in the US. Furthermore, they do not seem to have put much effort as yet into advanced separation techniques such as fluoride volatility and pyrometallurgical processing.

NUCLEAR METALLURGY

54. Soviet emphasis on the field of nuclear metallurgy continues to be very strong. The Soviet effort is being assisted slightly by the Satellite countries not only in coordinated production but also in coordinated research on such metals as lithium, beryllium, zirconium and thorium.

55. The 1958 Geneva Conference on Peaceful Uses indicated that the major research efforts in Soviet nuclear metallurgy have been concerned with uranium, plutonium and zirconium. There is reason to believe that nearly

all the essential metallurgy of uranium and plutonium for weapons and for conventional reactors is now known to Soviet metallurgists. Soviet research on plutonium alloys for possible solid and liquid reactor fuels apparently has been more extensive than that in Western countries. It is very possible that in the area of fused salts they have advanced to the stage that would permit the preparation in production quantities of the extremely pure metals required in nuclear reactor construction.

56. The exploitation of fundamental research has been emphasized by the Soviets especially with regard to structural materials such as zirconium for nuclear power reactors. It is believed that the Soviets are making use of the best features of both Soviet and US basic research. They have concentrated the efforts of about one hundred scientists on research on plutonium and plutonium alloys—a significantly large number for such a narrow field of science. We estimate that Soviet nuclear metallurgy is quite sufficient to satisfy the demands of a progressive nuclear program.

INSTRUMENTATION

57. Soviet reactor control and instrumentation is not as elaborate as that found in the US. Because the Soviet control systems are not under stringent safeguards criteria, they are easier to design and construct, and it appears that automatic and continuous precision control has not been emphasized.

MEDICINE AND BIOLOGY

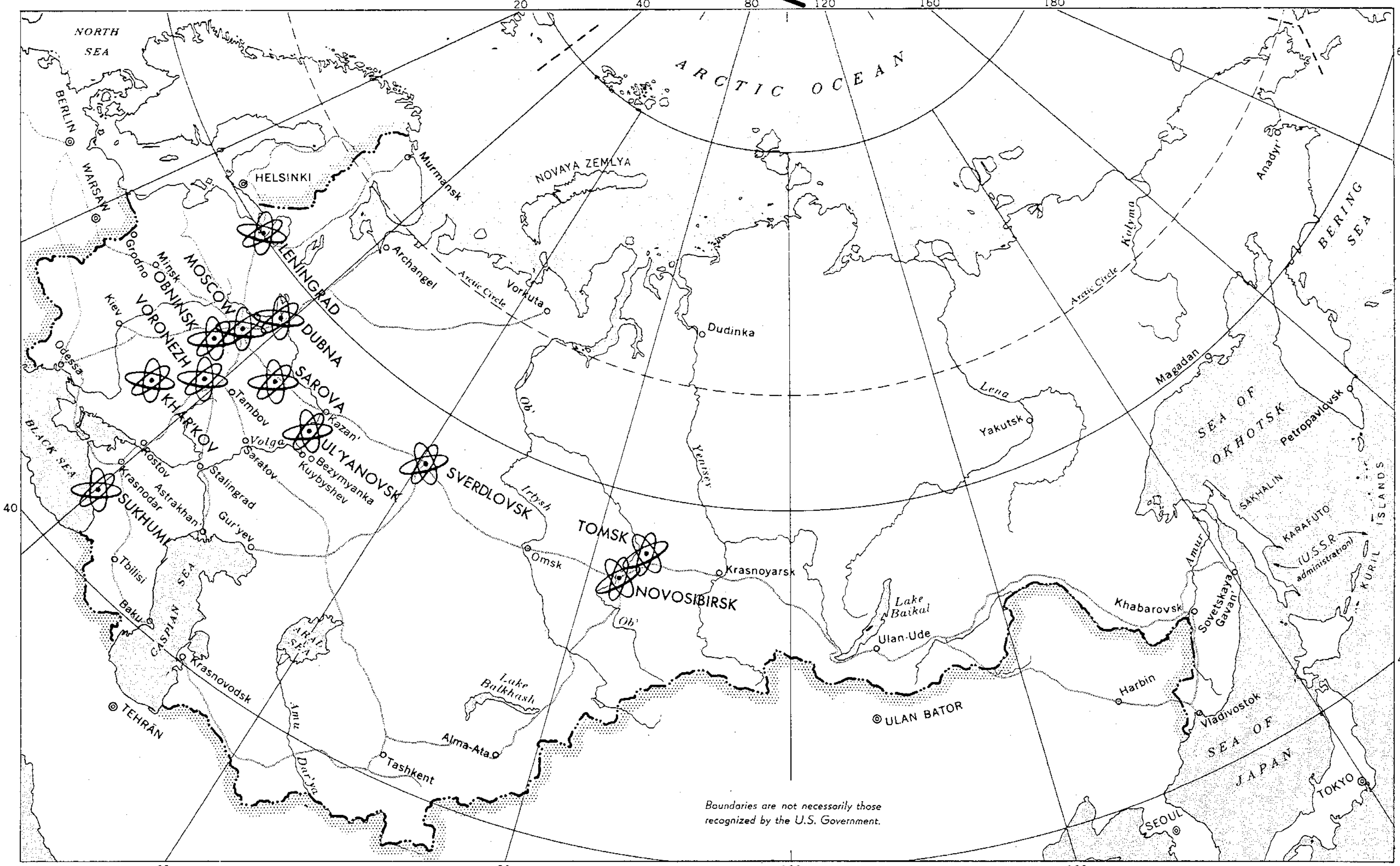
58. We estimate that within about ten years the Soviets will have enlarged their radiobiological program to fill present gaps in their research coverage, and their work will become more sophisticated. They may utilize their existing animal research facilities to begin competent long-term radiation genetic studies. This is a specific field in which the Soviets could forge ahead of the rest of the world. The Soviets will continue to investigate the effects of radiation on the central nervous system and will retain their present advantage over the West. The Soviets will remain behind the US in use of radioisotopes for diagnosis and therapy, in general radiobiology, in tracer work, in theory of action of radiation, and in health physics.

59. Soviet use of radiological techniques and radioactive materials in biological and agricultural research lags behind similar efforts in the West in both quantity and quality. However, some narrowing of this gap is expected during the period of this estimate.

LABORATORIES

60. Many laboratories throughout the Soviet Union have contributed to the atomic energy program although only a few have borne the main weight of the work. The Institute of Atomic Energy of the Academy of Sciences in Moscow (formerly Laboratory II) has worked primarily on heavy isotope separation and reactor development and is now the center of Soviet Controlled Thermonuclear Reactions (CTR) work. The adjacent Scientific Research Institute 9 has been responsible for the chemistry of uranium ores; uranium and plutonium metallurgy; and, with the Radium Institute in Leningrad, for development of chemical separations technology. The Radium Institute has also contributed cross-section data for the reactor program. The State Institute of Rare Metals (GIREDMET) has worked on the extraction and metallurgy of thorium, beryllium, zirconium, and other non-ferrous metals necessary to the program. In addition, the USSR Academy of Sciences operates a vast network of research institutes and laboratories, such as the Tomsk Polytechnic Institute, which are engaged in the broad fields of science and technology or occasionally in specialized fields, and at which some basic research pertaining to nuclear energy is conducted. Many educational institutes under the Ministry of Education are also engaged in generalized nuclear studies. Priority is being accorded to the nuclear sciences in the establishment of major new centers of science in Siberia. The development of these large research and training centers will gradually strengthen Soviet scientific capabilities. (See map showing major Soviet nuclear research centers—Figure 3.)

Figure 3



Present

Future

USSR
MAJOR NUCLEAR RESEARCH CENTERS

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Statute Miles

0 250 500 1000 1500 2000
Kilometers

Railroad (selected)

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IV. THE SOVIET NUCLEAR REACTOR PROGRAM

STATUS OF REACTOR TECHNOLOGY

61. The USSR has demonstrated excellent capabilities in reactor technology and has a diversified and comprehensive reactor program, which has grown considerably during the last three years. The USSR has made the greatest advances in the important fields of heat transfer, the superheating of steam directly in reactors, and the development of plutonium breeder reactors.

62. The present Soviet reactor capacity is devoted almost exclusively to plutonium production. Both graphite-moderated and heavy-water moderated types are in use. There is reason to believe that Soviet technology has been conventional in this field and has shown no outstanding advances.

63. The USSR is not committed to a specific power reactor type but instead is exploring the advantages of various types in prototype reactors and reactor experiments in an effort to obtain competitive nuclear power.

64. In the USSR, pressurized water technology appears to be the most advanced. All large power reactors which the Soviets plan to build in the USSR in the near future employ water as the coolant in either the pressure vessel or pressure tube configuration. However, the Soviets are definitely interested in boiling-water reactors, but they appear to be awaiting further development of pressurized water technology before utilizing this type of reactor. Little Soviet work has been conducted on organic moderated reactors or liquid-metal fueled reactors. Large Soviet power reactors are being designed to use fuel of relatively low enrichment (1 to 1.5%) and natural uranium. Soviet scientists are striving to obtain high burnups (for example, 8,000 MWD/ton in their pressurized water reactors) in fuel elements in order to decrease the cost of nuclear power. Soviet requirements for reactor safety are not stringent by Western standards; however, there is evidence of growing Soviet concern with reactor safeguards and controls.

65. It is estimated that the Soviets are still trying to overcome the materials problems present in the construction of high-temperature reactors for aircraft and rocket propulsion.

DEVELOPMENT HISTORY

66. There are three known major installations for reactor development in the Soviet Union. Two are administratively subordinate to the Academy of Sciences, although their research programs are probably under the operational control of the Ministry of Medium Machine Building. The first is the Institute of Atomic Energy in Moscow, which is directed by I. V. Kurchatov, and the second is the Thermotechnical Laboratory. The third reactor research center is composed of the laboratories at Obninsk which have now been organized into the Institute of Physics under the administrative control of the Chief Directorate for the Utilization of Atomic Energy. A new large establishment for reactor experiments is now being set up near Kuybyshev Lake in Ul'yanovsk Oblast'.[13]

67. The first reactor built in the USSR was the so-called "Fursov Pile," which is believed to have gone critical in 1947. This reactor was designed to demonstrate the feasibility of sustaining and controlling a chain reaction in a natural uranium-graphite pile. The Soviets' second experimental reactor, which was heavy-water moderated and cooled, went critical at the Thermotechnical Laboratory in Moscow in April 1949. Both these reactors furnished information which contributed to the final design of large plutonium production reactors.

68. The Soviets recognized early that they would have to build up their experimental facilities in order to develop more advanced reactor types. The Reactor Physical Technical (RPT), the Soviet equivalent of the US Materials Testing Reactor, was brought up to its

[13] The locations of nuclear research reactor sites are indicated in Figure 4.

rated power of 10 megawatts late in 1952. This reactor gave the Soviets the means to test fuel elements, cooling systems, and structural materials under actual reactor conditions and furnished information for the construction of a small 3–5 electrical megawatt (EMW) nuclear power station at Obninsk, which was put into operation in 1954. The RPT was preceded by a tank-type water-moderated and water-cooled research reactor (the VVR–II), which was used for shielding studies. This type reactor is being exported to five of the satellite countries. At the same time, the Soviets were undoubtedly carrying out exponential experiments and critical assembly work on other reactor types. Known reactor experiments have included the construction and operation of a beryllium-moderated reactor (the BFR), a UF_6 gaseous reactor, and several fast reactors employing plutonium as fuel (BR–1, BR–2, BR–3, and BR–5).

RESEARCH REACTORS AND REACTOR EXPERIMENTS

69. At the 1958 Geneva Conference on Peaceful Uses, the Soviets demonstrated that they have made marked advances in their research reactor program. Whereas at Geneva in 1955 the Soviets revealed only two high-flux research reactors, the Reactor Physical Technical (RPT) and the VVR–2, in 1958 they revealed the existence of three more research reactor types. A tank-type research reactor, the VVR–S, with a thermal neutron flux of 2.5×10^{13} neutrons/cm^2/sec has been exported to several satellites. A swimming-pool reactor, the IRT, was developed and put into operation in November 1957 at the Institute of Atomic Energy in Moscow. This reactor is the prototype for reactors which will be built at educational and research institutes in Sverdlovsk, Tomsk, Tashkent, Minsk, Tbilisi, Kiev, Leningrad and other cities. A chart of research reactors currently in operation in the USSR is shown in Table 5 on page 21.

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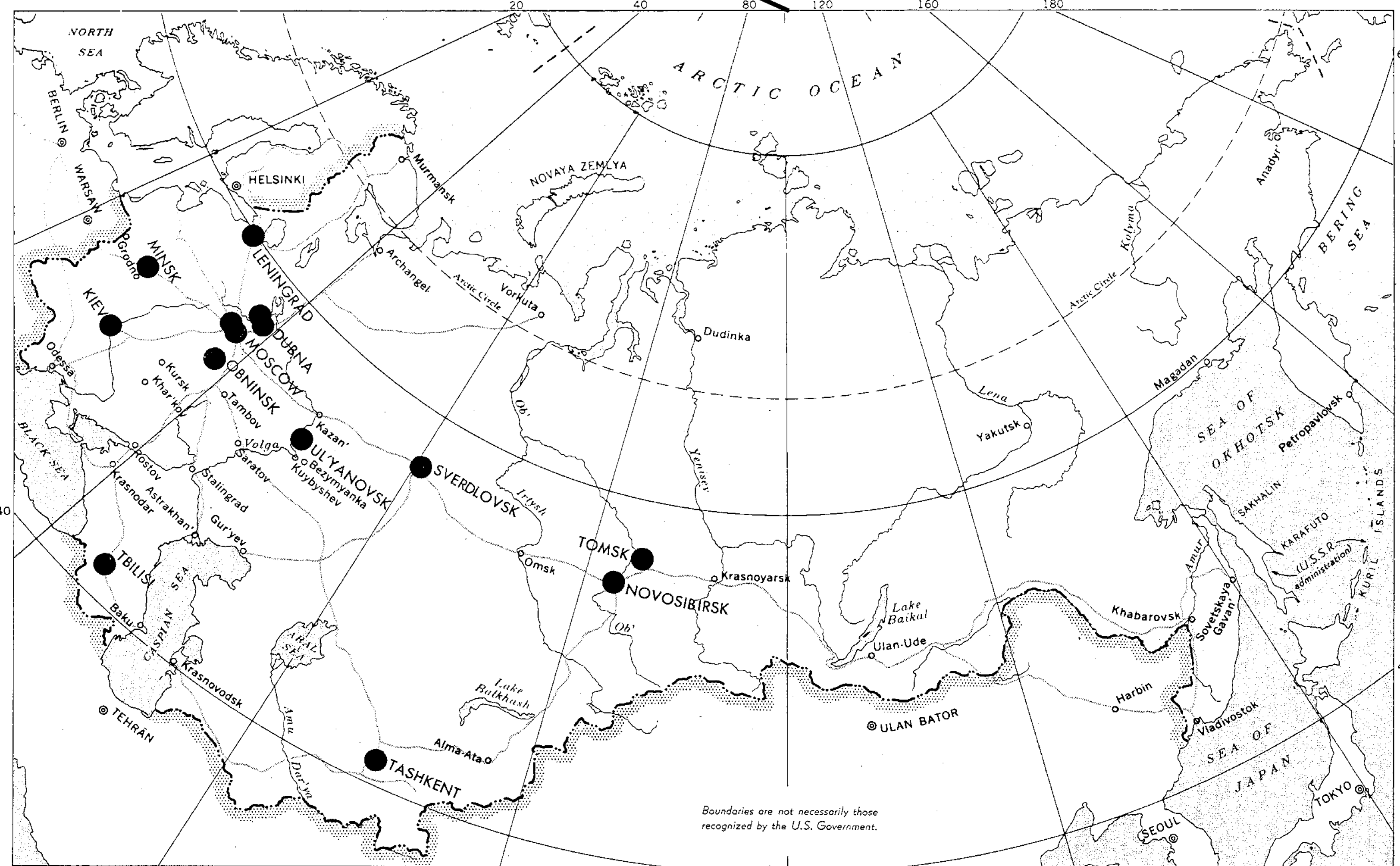
Figure 4



USSR
NUCLEAR RESEARCH REACTOR SITES

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Table 5

USSR RESEARCH REACTORS AND REACTOR EXPERIMENTS

Research Reactors

Reactor Designation	Location	Power Thermal (KW)	Max. Thermal Neutron Flux (neutrons/ cm^2/sec)	Fuel	Moderator	Coolant	Date Critical	Remarks
Fursov Pile	Moscow, Inst. of AE	10 (Max.)	. .	45 tons of natural U	Graphite	Air	1947	Similar to US CP–1, served as prototype for 1st Soviet production reactors.
TR	Moscow, Thermotech. Laboratory	500	2.2×10^{12} (average)	2,100 Kg of natural U	Heavy Water 4.5 tons	Heavy Water	Apr 1949	Prototype for Soviet heavy-water production reactors.
TR (rebuilt)	Moscow, Thermotech. Laboratory	2,500	2.5×10^{13}	270 Kg of enriched U	Heavy Water	Heavy Water	June 1957	9 vertical channels, 52 horizontal channels.
RPT	Moscow, Inst. of AE	10,000	8×10^{13}	1,200 Kg of 10% enriched U	Graphite and Water	Water	Apr 1952	Full power Dec. '52. Five in-pile loops, 3 water-cooled, 1 gas-cooled, 1 liquid metal cooled, 4 vertical channels.
RPT (rebuilt)	Moscow, Inst. of AE	20,000	1.8×10^{14}	6.1 Kg of 90% enriched U	Graphite and Water	Water	1957	Reconstruction accomplished during normal shut-downs. Now 11 in-pile loops, 15 vertical channels.
VVR–2	Moscow, Inst. of AE	300	2×10^{12}	35 Kg of 10% enriched U	Water	Water	1952	Tank-type reactor designed for testing of shielding materials and configurations.
VVR–2 (rebuilt)	Moscow, Inst. of AE	3,000	4×10^{13}	45 Kg of 10% enriched U	Water	Water	1955	Now has 5 horizontal channels with choppers, 3 vertical channels, and a "neutron multiplier" (spent fuel elements in a tank adjacent to reactor).
VVR–S	Moscow, Moscow State Univ.	2,000	2.5×10^{13}	60 Kg of 10% enriched U	Water	Water	1955	Tank-type, 10 vertical channels, 9 horizontal channels. Supplied to Rumania, Hungary, Czechoslovakia, E. Germany, Poland, and Egypt.
IRT	Moscow, Inst. of AE	2,000	3.2×10^{13}	40 Kg of 10% enriched U	Water	Water	Nov 1957	Swimming-pool prototype for use in universities and insts. A 1,000 KW version, IRT–1,000 will be built in Bulgaria and in many cities in USSR.

Table 5 (*Continued*)

Reactor Designation	Location	Power Thermal (KW)	Max. Thermal Neutron Flux (neutrons/ cm^2/sec)	Fuel	Moderator	Coolant	Date Critical	Remarks
VVR–M	Leningrad	10,000	1 x 10^{14}	20 Kg of 20% enriched U	Water	Water	End 1958	Beryllium reflected, used for isotope production, prod. of trans U elements; also neutron diffraction studies probably in connection with solid state work in Leningrad.
VVR–Ts	....	10,000	1 x 10^{14}	25 Kg of 20% enriched U	Water	Water	..	Specialized radio-chemical research reactor.
Intermediate Flux Trap	Possibly Moscow Inst. of AE	50,000	2.2 x 10^{15}	Unknown amt. of 90% enriched U	Water	Water	Probably 1959–60	Be or BeO reflected, central water cavity where max. thermal neutron flux is obtained.
Pulsed Reactor	Being built at Obninsk for use at Dubna Joint Inst. of Nuclear Research	~5,000	~10^{17} during burst ~10^{15} average	1 Kg of U–235 in 15 liters of water	Water	Water	1959	Reactor is flashed by moving reflector in; heat pushes part of core solution out of container, making core subcritical.
			Neutron Flux	Reactor Experiments				
BR–1 Fast Reactor	Obninsk	0.05		Pu	None	None	Early 1955	Uranium and copper reflectors.
BR–2 Fast Reactor	Obninsk	100	10^{14}	Pu-U	None	Mercury	Early 1956	Uranium reflector.
BR–3 Combined Fast-Thermal Reactor	Obninsk	0.05	..	Pu	None	None	Mid-1957	Uranium and water reflector.
BR–5 Fast Reactor	Obninsk	5,000	10^{15}	Pu Oxide	None	Sodium	1958	Uranium and nickel reflector.
UF_6 Gas-Fueled Reactor	....	1.5	2.7 x 10^{10}	UF_6 with 90% enriched U	Beryllium Metal	None	Aug 1957	
Beryllium Physical Reactor (BFR)	Obninsk	0.05	..	U_3O_8 with 2% enriched U metal	Beryllium Metal	None	Aug 1954	Zero-power critical assembly, bare and reflected.
Isotope Reactor (IR)	Possibly Moscow Inst. of AE	50,000	3–4.5 x 10^{13}	3 tons of 2% enriched U metal	Graphite	Water	1952	Experimental facility for production of isotopes.

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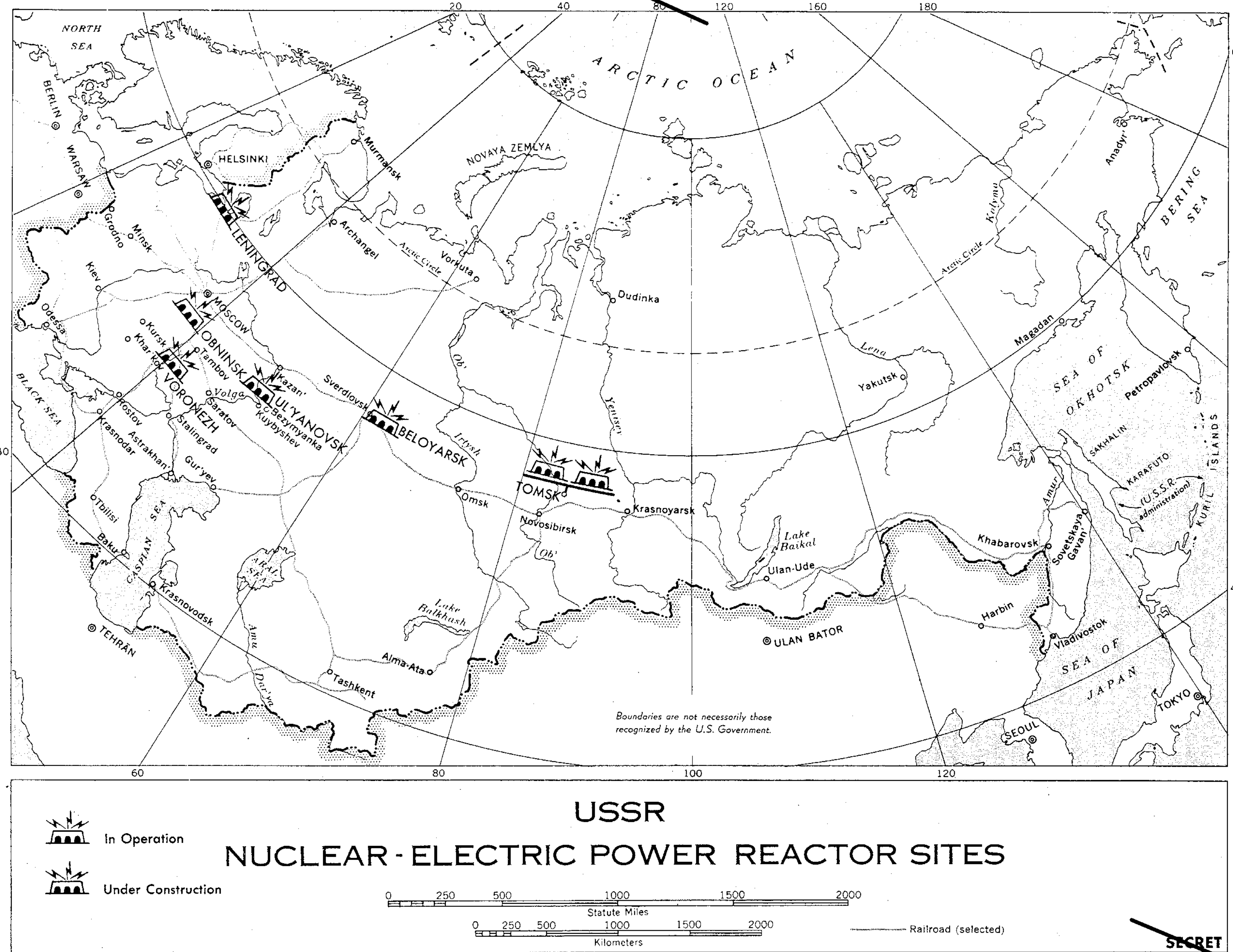
Figure 5



USSR
NUCLEAR - ELECTRIC POWER REACTOR SITES

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70. The Soviets are also making progress in the development of high flux research reactors of novel design, such as the flux-trap and pulsed types. They are building a 50-megawatt intermediate research reactor using the flux trap principle, which is expected to yield continuous fluxes of 2.2 x 10^{15} neutrons/cm^2/sec. A pulsed reactor is being built at Obninsk for the Joint Institute of Nuclear Research at Dubna. This reactor should also produce average fluxes in the order of 10^{15}. Such reactors are useful for radiation damage studies and large-scale production of transuranium elements. The Soviet Union appears to be prepared to go ahead with such projects on the basis of very limited experimental data.

POWER REACTORS AND REACTOR EXPERIMENTS

71. It is almost certain that the Soviets will fail by a period of at least two years to reach the nuclear power objectives laid down in the Sixth Five-Year Plan. This Plan called for the installation of 2,000–2,500 megawatts of nuclear generating capacity by the end of 1960. At the present time, the USSR avoids mention of any fixed goal in terms of nuclear megawatts installed by a certain date. The Soviets are proceeding cautiously with the construction of power reactors of several different types to determine the economic feasibility of each. We estimate that they will obtain an additional amount of electric power from dual-purpose reactors.

72. The present plan for construction of nuclear power stations with sites and estimated dates of completion is shown in the chart (Table 6 on page 24). It is estimated that the USSR will have 2,000 megawatts of installed nuclear generating capacity by 1963. The Soviets have indicated that they will review the operating experience with their nuclear power stations and select particular reactor types for their "second-round" of large power stations. It is impossible to predict which reactor types the Soviets will select. However the majority of large power stations under construction are of the graphite-moderated, pressure-tube reactor type, one of which uses nuclear superheat. The locations of present and planned nuclear-electric power reactors is indicated in Figure 5.

Table 6

SOVIET NUCLEAR POWER STATIONS AND EXPERIMENTAL CENTERS

Nuclear Power Stations

Location	No. of Reactors and Type	Elec. Power (Total MW)	Thermal Power (Total MW)	Fuel Loading Per Reactor	Conversion Ratio	Amount Pu Produced Annually (Kg)	Fuel Lifetime	Estimated Date of Full-Pwr. Operation	Remarks
Possibly Tomsk	6 Dual-purpose	600	3,000 claimed 3,600 assumed	220–250 tons of natural U metal	0.8 assumed	1,080	..	1962	First reactor in operation in September 1958.
Beloyarsk	4 Graphite-Moderated, Water-Cooled, Pressure Tube Configuration	400	1,140	90 tons of 1.3% U metal	0.65 at beginning of cycle, 0.55 at end	260	2 yrs.	1962	Employs nuclear superheat. Estimated schedule: 1st reactor, 1959; 2nd reactor, 1960; 3rd, 1961; 4th 1962.
Voronezh	2 Water-Moderated Water-Cooled, Pressure Vessel Configuration	420	1,520	23 tons of 1.5% UO_2 and 17 tons of natural UO_2, 820 Kg U–235	0.8	440	7 mos.	1960	Zr-alloy clad fuel elements. 1st reactor probably in operation in 1959 or early 1960.
Leningrad	SAME AS VORONEZH STATION							1962–63	1st reactor probably in operation in 1961–62.
	1 Fast Plutonium Breeder	250	1,000	..	1.8–2.0 breeding ratio claimed.	720–800	..	1965–66	Now in early planning stage.
Obninsk	1 Graphite-Moderated, Water-Cooled, Pressure Tube Configuration	5	30	550 Kg of 5% U metal	0.3	3	100 days	1954	First Soviet nuclear power station. Prototype of Beloyarsk reactors. Used extensively for experiments, as well as power production.
Obninsk	1 Package Power, Water-Moderated, Water-Cooled, Pressure Vessel	2	10	..	0.7 assumed	3	..	1959	Will be assembled for testing at Obninsk and probably moved to another location after testing.
Ul'yanovsk	1 Boiling Water Reactor	50	240	..	0.60 assumed	58	..	1961	Same type fuel element as large PWR's.

Ul'yanovsk	1 Fast Plutonium Breeder	50	200	..	1.6–1.8 breeding ratio claimed	50	..	1962	Designation, BN-50; sodium-cooled with intermediate NaK loop; may use neutral diluents in fuel elements.
Ul'yanovsk	1 Graphite-Moderated, Sodium-Cooled	50	180 assumed	..	0.60 assumed	43	..	1962	Intermediate NaK loop.
Ul'yanovsk	1 Homogeneous Thorium Breeder	5 assumed	35	..	1.0 assumed	14 on hand after U-235 cycle reached	..	1962	Suspension or solution of U in heavy water, boiling.

PRODUCTION REACTORS

73. As stated in paragraph 67, it is believed that experience gained with the Fursov Pile at the Institute of Atomic Energy and the heavy-water reactor at the Thermotechnical Laboratory contributed to the final design of early production reactors in the USSR. It is further believed that Soviet plutonium production reactors of both the graphite and heavy-water moderated types are still being built. The Second Geneva Conference revealed that the large new Soviet dual-purpose reactor is graphite-moderated and water-cooled. A detailed discussion of Soviet plutonium production sites and production estimates is given in Section VI, paragraphs 122 and 127.

PROPULSION AND SPECIAL-PURPOSE REACTORS

Naval and Marine Reactors

74. The Soviet Union has exhibited a definite interest in nuclear propulsion for several types of merchant and naval vessels.

a. The first Soviet nuclear-powered surface ship, the icebreaker LENIN, was launched at Leningrad in December 1957, and in late 1958 three nuclear propulsion reactors of the pressurized water type (PWR) were installed in this ship. We expect that the LENIN will be put into operation during the latter half of 1959.

b. In the past few years there has been an increasing number of reports indicating the existence and production of nuclear-powered submarines. However, we have no conclusive evidence that any are in operation. We estimate, based on the status of reactor technology evidenced in papers concerning the LENIN and the large PWR for electric power production, that the earliest date that a nuclear propulsion reactor for a submarine could have been available for installation was late 1957, and the Soviets could have had one or possibly as many as three nuclear submarines in operation by the end of 1958. We continue to estimate that by mid-1963 the Soviets could have about 25 nuclear powered submarines.[14]

c. All Soviet nuclear propelled vessels constructed through 1962 will probably utilize the PWR with enriched fuel. After 1962, the Soviets will have developed all of the following reactor types sufficiently to be able to apply them to nuclear propulsion: boiling water, gas-cooled cycle, sodium-cooled, and homogeneous.

Aircraft and Rocket Reactors

75. Although we have no firm evidence, a thorough survey of the literature and current Soviet research and development indicates that the Soviets intend to develop an aircraft nuclear propulsion system. We estimate the Soviets are capable of having a flying testbed airborne at any time in the next few years with at least one nuclear power unit providing useful thrust during a phase of the flight. The results of this program are expected to lead to a useful nuclear propulsion system. We estimate that a prototype reactor system suitable for cruise propulsion on nuclear heat alone for subsonic aircraft could be available to the Soviets by 1962, but that it would be 1964 before reliable reactor systems could begin to become available for operational use.[15]

Supersonic applications of ANP would require a long test and development program, and we estimate that a prototype will not be achieved until after 1964. They have probably conducted feasibility studies on several possible reactor coolant systems for aircraft nuclear propulsion purposes. It is not known whether the coolant system to be finally utilized will be mated to either turboprop or turbojet air-

[14] NIE 11-4-58.

[15] The Assistant Chief of Staff, Intelligence, USAF; the Director for Intelligence, Joint Staff; and the Assistant to the Secretary of Defense for Special Operations do not agree with the first four sentences of paragraph 75, and believe instead that the USSR has been engaged in the high priority development and testing of reactor components and sub-systems for some time, and that a reactor system suitable for nuclear propulsion of subsonic aircraft could be available to the Soviets in 1962.

craft engines. The Soviet Union has also probably conducted feasibility studies on nuclear ramjet engines.

76. It is estimated that the Soviet Union is at this time engaged in developing a nuclear rocket engine. Dr. Leonid I. Sedov was quoted at the International Astronautic Congress in Rome, September 1956, as saying that Soviet atomic rocket research was progressing at various institutes throughout the Soviet Union. Although the Soviets have a well-rounded program of research in high-temperature refractory compounds and high-flux reactor facilities are now under construction for materials testing within the Soviet Union, it is estimated that no more than preliminary construction of a nuclear rocket test facility has begun.

77. It is known that the Soviet Union has conducted metallurgical research which is also applicable to a nuclear ramjet program.

Nuclear Propulsion for Land Vehicles

78. It is estimated that a program for the nuclear propulsion of land vehicles began about the time the USSR realized that suitable reactor types were probably feasible. Since 1954, the Soviets have made many references to the feasibility of nuclear propulsion for land vehicles and to the existence of a development program. The announced Soviet program includes nuclear propulsion for railway locomotives, truck-trailer trains for cross-country hauling, and "commercial vehicles." Among the reactor types under study by the Soviets which are potentially adaptable to land vehicles are the pressurized-water, homogeneous boiling, and the liquid-metal reactors.

Small Power Reactors

79. Small nuclear power plants, both stationary and mobile, with military as well as industrial construction and agricultural applications, have been officially announced as part of the Soviet reactor development program. The mobile stations are to be mounted on rail or caterpillar, and special military types are reportedly under study which will be transportable in a "normal" transport plane in such a way that the various reactor parts can be air-dropped and then reassembled in a very short time.

80. A transportable station intended for use at industrial construction sites lacking conventional sources of electrical energy was reported at the 1958 Geneva Conference on Peaceful Uses. This package reactor station uses a pressurized-water reactor with a 2,000 kilowatt capacity assembled in a vessel about one meter in diameter and 2.2 meters in height. Water under a pressure of 120 atmospheres is used as coolant and moderator. This station was scheduled to be assembled at Obninsk at the end of 1958 to undergo tests. Although no scheduled dates are known for completion of other projects in the package reactor program, the announced goals appear to be qualitatively consistent with the present status of Soviet reactor technology.

V. THE SOVIET CONTROLLED THERMONUCLEAR REACTIONS PROGRAM

81. Soviet research on Controlled Thermonuclear Reactions (CTR) appears to have begun in the 1950–51 period with some basic theoretical work by I. Ye. Tamm and A. D. Sakharov. The Soviet program remained under tight security until April 1956 when I. V. Kurchatov, the Director of the Institute of Atomic Energy (IAE), Moscow, presented a paper at Harwell, England, which gave the technical details and recorded data of experiments utilizing a high current discharge in a rarefied gas in attempts to attain fusion of the deuterium atoms with resulting release of energy.

82. The original Soviet experimental work was carried out with equipment of straight tube geometry, with which they were able to obtain approximately one million degrees temperature. Although neutrons were detected, the Sovets realized that they were not of thermonuclear origin.

83. Soviet research on straight tube, dynamic pinch experiments continued but on a decreasing scale. At the time of the International Conference on Ionization Phenomena

in Gases at Venice, 11–15 June 1957, it was evident that the Soviets considered this approach held little promise of success. However, they obtained sufficient information at the Venice Conference to permit them to recommence this research with at least a partially stabilized pinch discharge. This work was varied and a torus geometry was introduced. At the Venice Conference the Soviets also disclosed that they had independently developed the "magnetic mirror" and some of the other techniques known to the West.

84. Information obtained at the Second International Conference on Peaceful Uses of Atomic Energy, Geneva, 1–13 September 1958, indicated that the USSR has an extensive program, competently staffed, which includes work on essentially all the known approaches to the problem of obtaining useful power from controlled thermonuclear reactions. Also at the Second Geneva Conference, the Soviets revealed the existence of their ALPHA. This is a large torus apparatus, a slightly larger copy of the British ZETA, which was apparently constructed during the period when the United Kingdom was over-optimistically announcing their success with ZETA. No results of work on this machine have been published.

85. Research has been carried out using "mirror" geometries, or the so-called "magnetic-cork." Late in August 1958, just prior to the opening of the Geneva Conference, the Soviets revealed their largest machine yet . . . OGRA. This is a large "mirror" machine, making use of molecular beam injection and collision breakup scheme for production of a plasma within the magnetic field. They failed to make use of the much more favorable "arc-breakup" scheme but have indicated that such a modification might possibly be made. OGRA had not yet then been operated owing to difficulty in obtaining the necessary vacuum.

86. Western scientists visiting Moscow in October 1958 reported a smaller version of OGRA, this one called OGRINA. They further reported that a beam has never been successfully injected into OGRINA. The reason for this difficulty is unknown. Construction of large, complex machines such as OGRA, without first proving the principles involved in experimental devices, indicates that the Soviet approach to this problem follows the so-called "brute force" approach found in much of Soviet technology.

87. Research on stationary processes, quite similar to the highly published STELLERATOR process, is being conducted at Sukhumi under the direction of R. Demirkhanov.

88. There appear to be two major efforts in CTR research in the USSR, one of which is under the direction of L. A. Artsimovich at the Institute of Atomic Energy, Moscow. M. A. Leontovich, aided by a few capable assistants provides the theoretical studies to support the experimental work of Artsimovich, and I. M. Golovin is in specific charge of the work on OGRA. The other, under Demirkhanov at Sukhumi, was apparently unknown to the staff of the Moscow Institute until the advent of the Geneva Conference. Demirkhanov gave the impression that he had a fairly large staff working on the problem at Sukhumi and that he was not revealing all the details of his program. Practically all of the publications released to date by the USSR in the field of CTR pertain to work done at the Institute of Atomic Energy, although there is evidence of work being conducted at other locations.

89. There is evidence that the over-all scope of the Soviet controlled thermonuclear research program is comparable to and almost on a par with that of the Western powers. However, analysis of the compiled evidence indicates that the Soviets lack a complete understanding of the problem of stabilization of the pinch discharge but are well advanced in the confinement techniques and energy loss mechanisms. Their research on mirror geometries appears less complex than that of the West; however, they have gone directly to the massive OGRA device in contrast to the Western approach to the problem. Their theoretical studies have indicated the possibilities of limitations in some approaches to controlled fusion not previously recognized in the West.

90. In general, the Soviet program of research directed at obtaining controlled thermonu-

clear reactions is well staffed with capable scientific and technical personnel, adequately supplied with money and equipment and provided with sufficient incentives and demand to assure a well-rounded, progressive program. Such a program is deemed capable of producing good research toward attaining a controlled thermonuclear reaction as soon as any other group in the world, but useful energy cannot be expected to be obtained for a long time.

VI. THE SOVIET NUCLEAR MATERIALS PRODUCTION PROGRAM

SOVIET URANIUM ORE PROCUREMENT

Present Mining and Milling Activities

91. Information on East German (GDR) ore grades as well as increases in GDR uranium ore shipments to the USSR have caused us to raise slightly the estimates of contained uranium in European Satellite ore. The publication of the Polish government production figures has caused us to lower somewhat the estimate of Polish production. We have excellent documentary information on Hungarian uranium mining operations which indicates a nominal production until about 1958, after which production will gradually rise to a substantial rate. A chemical concentrating plant will be in operation in Hungary by 1959. Some new quantitative information is available on the other Satellites, notably Czechoslovakia, Bulgaria, and Rumania but the reliability of the information for these latter countries is considerably less. Reliable information has been received indicating that ore procurement from the Chinese Peoples Republic, though now still small, will rise during the next few years.

92. The USSR has continued to exploit well-known deposits and develop new areas during 1958. However, quantitative information on uranium ore production within the USSR continues to be limited for most uranium mining areas, although the situation improved slightly during 1958. We have obtained some information on the Krivoy Rog district from a competent western uranium geologist who visited one of several uranium mines there and was able to make a fairly firm estimate of the production from this one mine. Well-known deposits such as those in the Fergana Valley were probably worked at the same rate as in 1957, but there is some evidence that mining operations have been curtailed in the low-yield, inaccessible deposits of northeastern Siberia.

93. An analysis of ground photographs on a uranium ore concentrating mill near Pyatigorsk in the Caucasus built several years ago indicates that the Russians have well-constructed, modern mills probably utilizing high yield recovery processes.

94. The estimated ore production by country for the Soviet Bloc is presented in Table 7 on page 30. While the reliability of these estimates varies greatly from country to country, actual total cumulative production is believed to be not more than 30% smaller or 50% greater than the estimated values through 1958. These estimated amounts are more than sufficient to support current estimates of fissionable material production and allow stockpiling of considerable tonnages of uranium oxide or metal. (The location of Satellite and Soviet uranium mining localities is shown in Figures 6 and 7.)

Future Sources and Production

95. The US Geological Survey estimates that the Soviet Bloc has reserves of several hundred thousand tons of uranium in medium grade ore deposits and an even greater quantity in low grade deposits. Many of these reserves are within the Soviet Union and the Chinese Peoples Republic and could be exploited by present ore recovery methods. By continuing present trends through the various countries of the Soviet Bloc, a reasonable estimate can be made of future ore procurement, although the possible error in estimation will be necessarily very large.

96. There is reliable information that ore production in the GDR will begin to decrease by 1959, probably by a few hundred tons per year. The level of prospecting in Eastern Czechoslovakia, a geologically promising area for uranium, suggests an intention to increase or at least maintain production in that country. We judge by estimated reserves that production in Bulgaria may continue to increase until 1970. The USSR seems uninterested in Polish ore, which is believed to be of low grade, and at one time attempted to break the Soviet-Polish purchasing agreement. Subsequent information indicates that the Poles would cease delivery of uranium ore after 1958 and use their production for domestic purposes. Extensive prospecting continues in Rumania and new deposits are expected to be discovered. Detailed plans for Hungarian expansion through 1962 suggest this country may become a major producer by 1967. Reliable information indicates that the Chinese Peoples Republic, with Soviet assistance, is now implementing a major ore production program with the possible implication that not all the resulting ore will go to the USSR.

97. In summary, while there is good reason for expecting a decrease in GDR ore production over the next ten years, the over-all Bloc production is expected to increase considerably through 1964 in a manner similar to that tabulated in Table 7.

98. Estimates beyond that date are somewhat speculative since actual production will depend upon Soviet policies and plans. However, our present analysis of trends indicates that the total cumulative production will have

Table 7

ESTIMATED SOVIET BLOC URANIUM ORE PRODUCTION UP TO 1964

(Metric Tons of Recoverable Uranium, Rounded)

	USSR	E. Germ.	Czech.	Bulgaria	Poland	Rumania	Hungary	China	Total Annual	Total Cumulative
Pre 1946 Stocks	20	200	70	Nominal	..	..	..	..	300	300
1946	130	60	30	Nominal	..	..	..	..	200	500
1947	170	300	50	20	Nominal	..	..	..	550	1,000
1948	500	500	150	30	20	..	..	..	1,200	2,200
1949	680	1,000	250	60	40	..	..	..	2,000	4,300
1950	820	1,300	400	100	40	..	..	..	2,700	6,900
1951	1,300	1,700	500	150	40	..	..	Nominal	3,700	11,000
1952	1,700	2,400	600	200	40	50	..	40	5,000	16,000
1953	2,200	3,300	800	300	40	150	..	40	6,800	22,000
1954	2,900	3,800	1,000	400	40	300	..	60	8,500	31,000
1955	4,000	4,300	1,200	600	40	500	..	60	10,700	42,000
1956	4,800	4,600	1,400	800	40	600	Nominal	80	12,300	54,000
1957	5,600	5,000	1,600	900	40	700	100	100	14,000	68,000
1958	6,000	5,000	1,600	1,000	40	700	200	200	14,700	83,000
1959	6,400	4,800	1,700	1,000	0	800	300	400	15,400	98,000
1960	6,900	4,600	1,700	1,000	0	800	400	500	15,900	114,000
1961	7,400	4,600	1,800	1,200	0	800	500	700	17,000	131,000
1962	7,800	4,400	1,800	1,200	0	1,000	600	1,000	17,800	149,000
1963	8,200	4,400	2,000	1,200	0	1,000	700	1,200	18,700	168,000
1964	8,700	4,400	2,000	1,400	0	1,200	800	1,200	19,700	187,000

The European Soviet Satellites
PRINCIPAL URANIUM MINING AREAS

0 100 200 300 400 Statute Miles

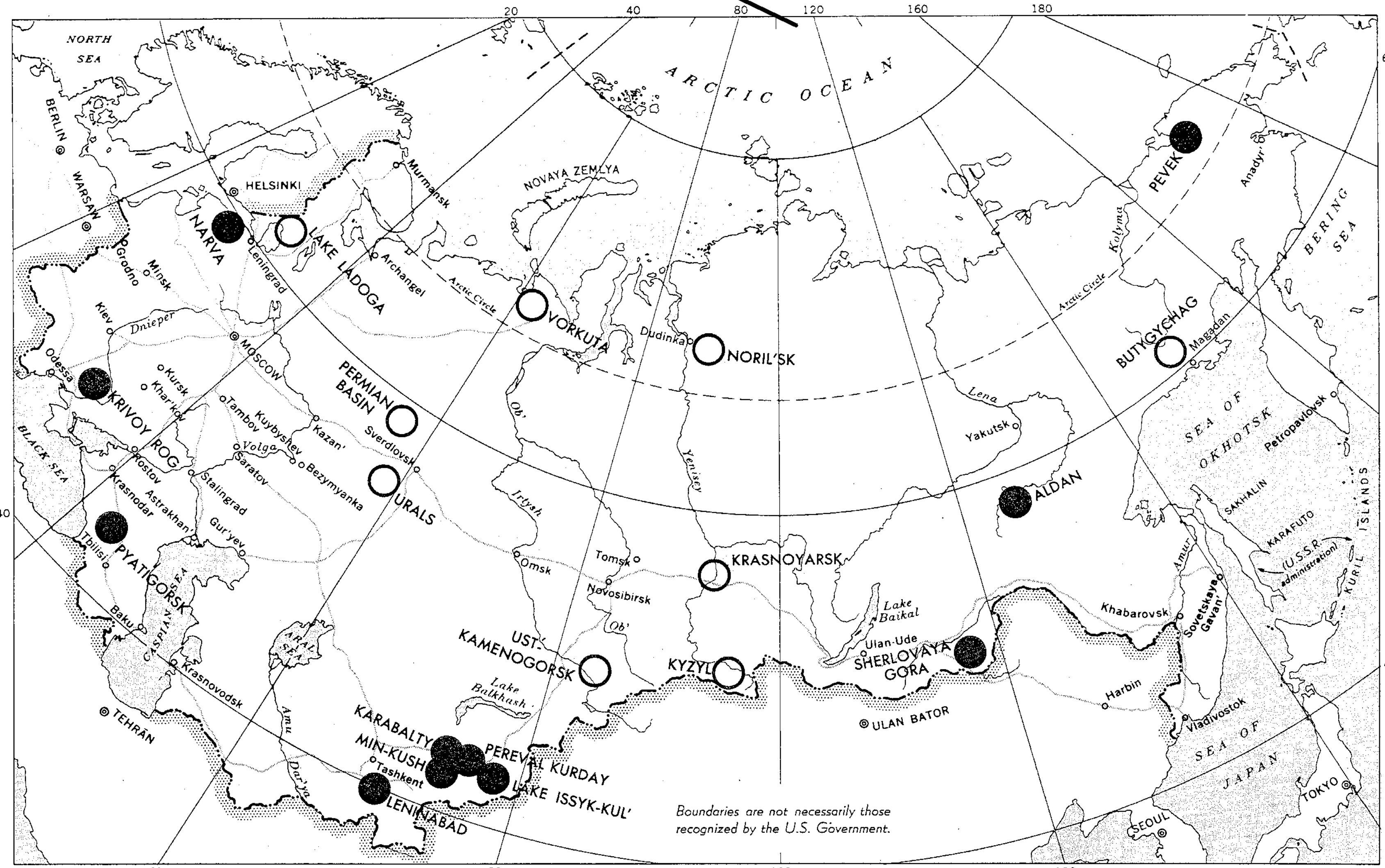
0 100 200 300 400 Kilometers

Selected railroad

~~SECRET~~

~~SECRET~~

Figure 7



USSR
PRINCIPAL URANIUM MINING AREAS

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increased to about 295,000 metric tons of recoverable uranium by mid-1969.

URANIUM METAL

99. Uranium metal is produced on a large scale at three known locations in the Soviet Union: Elektrostal', near Moscow; Glazov, just west of the Urals; and Novosibirsk, in central Siberia. We have good information on a substantial increase in production at Elektrostal' between late 1949 and late 1957 and of a major expansion in facilities which started at the Novosibirsk plant about two years ago. Available intelligence on these three sites clearly indicates that their uranium metal production capacity is adequate to support the Soviet plutonium production program as estimated herein.

LITHIUM

100. [redacted]

101. [redacted]

102. It is probable that the USSR has been producing enriched lithium isotopes in quantity since at least 1955, although the locations and capacities of Soviet lithium isotope separation plants are unknown. Substantial increases in the production of lithium compounds within the USSR have occurred in recent years. Probable lithium production exceeds the amounts of natural lithium required for the manufacture of the thermonuclear weapons. However, Bloc attempts in the last two years to procure major quantities of lithium ore from the West suggest that either the production of suitable lithium concentrates within the USSR is not yet at the desired level or that its cost is considerably above the open market price outside the Bloc.

HEAVY WATER (D_2O)

103. Limited production of heavy water started in 1947 at the Chirchik Electrochemical Combine. Five additional facilities employing a water electrolysis-catalytic exchange method went into production between 1948 and 1950. A seventh plant, which used a hydrogen sulfide-water exchange method, went into operation at Aleksin in 1948.[16]

Table 8

SOVIET HEAVY WATER PRODUCTION[a]
(Metric tons of D_2O)

Mid-Year	Annual	Cumulative Production
1946	Neg.	Neg.
1947	2	2
1948	4	6
1949	19	25
1950	45	70
1951	60	130
1952	65	195
1953	70	265
1954	75	340
1955	80	420
1956	90	510
1957	90	600
1958	90	690
1959	90	780

[a] See paragraph 106 for comments on the reliability of these figures.

104. The Soviets recently disclosed that an industrial scale plant using the hydrogen distillation process had been built. There is fairly strong evidence that such a plant had been installed by 1953 at the Chirchik heavy water plant which had been employing a water electrolysis-catalytic exchange system. Total production of D_2O would still be governed by the amount of electrolytic hydrogen available; however, the deuterium recovery therefrom could be increased by at least 50% because of the greater efficiency of the distillation system.

[16] For the locations of Heavy Water Plants see Figure 8.

105. By late in 1947 work was also under way at Noril'sk on a plant using an ammonia distillation system. This plant probably began production about mid-1955. No other heavy water plants have been identified in the Soviet Union.

106. We estimate the annual heavy water production of the known eight plants to be about 90 metric tons per year. Because it is quite possible that we are unaware of one or more operating plants, a range of error of plus 50% to minus 25 percent places the estimate within a probable range of 70 to 140 metric tons per year.

URANIUM-233

107. Active Soviet interest in thorium-bearing minerals started about mid-1946 with the formation of a special directorate for their exploitation. Although part of this interest lay in the requirement for lanthanum which is found in thorium-bearing minerals and was needed for the Soviet plutonium separation chemical plant, German scientists at Elektrostal' were also required to design a process for the production of pure thorium oxide. Subsequently, the USSR acquired considerable thorium stocks. However, until the appearance of U-233 in the high-yield test of JOE 19, 22 November 1955, the only certain production of U-233 from thorium was the research quantities mentioned at the Geneva and Moscow Conference on Atomic Energy. There has been no detected weapon use of U-233 since this November 1955 shot, and it appears probable that the Soviets are not making important quantities of U-233 for weapon stockpiling at present. The interest in breeder reactors using the thorium cycle in their power reactor program does not necessarily suggest a future weapon utilization of the material.

TRITIUM

108. The first known Soviet interest in tritium was revealed by the publication in late 1948 of a comprehensive review of the literature on tritium by M. B. Neyman, a staff member in the Soviet atomic energy program. Returned German scientists report that by 1952 tritium was available in their laboratories for research. Evidence of [redacted] weapons in 1957 and 1958 indicates that there is an appreciable demand for tritium in the Soviet weapons program. Production of tritium up to mid-1959 is estimated at not more than 10% of the total plutonium equivalent.[17] After mid-1959, this percentage is expected to increase. This increase cannot be predicted but in any case would be limited to 50% of production reactors' and 5% of power reactors' capacity for plutonium production.

U-235 PRODUCTION

Background

109. The existence of large gaseous diffusion U-235 production plants at Verkhneyvinsk in the central Urals and near Tomsk in central Siberia is positively confirmed. Information from several sources on atomic energy construction activities near Angarsk in the Lake Baikal region indicates the probable existence of a gaseous diffusion complex, although positive confirmation has not yet been obtained. Thus, we know the Soviet U-235 program includes at least two and probably three large sites, as shown on the Map (Figure 8).

a. The Verkhneyvinsk plant started a small-scale plant production in 1949, but this early plant was almost a total failure. [redacted] There is good evidence of large-scale plant expansion since that time and of continuation of this expansion at least through 1960.

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[17] The term "plutonium equivalent" is used because our method of estimation does not permit us to distinguish between plutonium, U-233, tritium, or other reactor-produced isotopes. For planning purposes, 10 grams of tritium is considered equal to 1 kilogram of plutonium.

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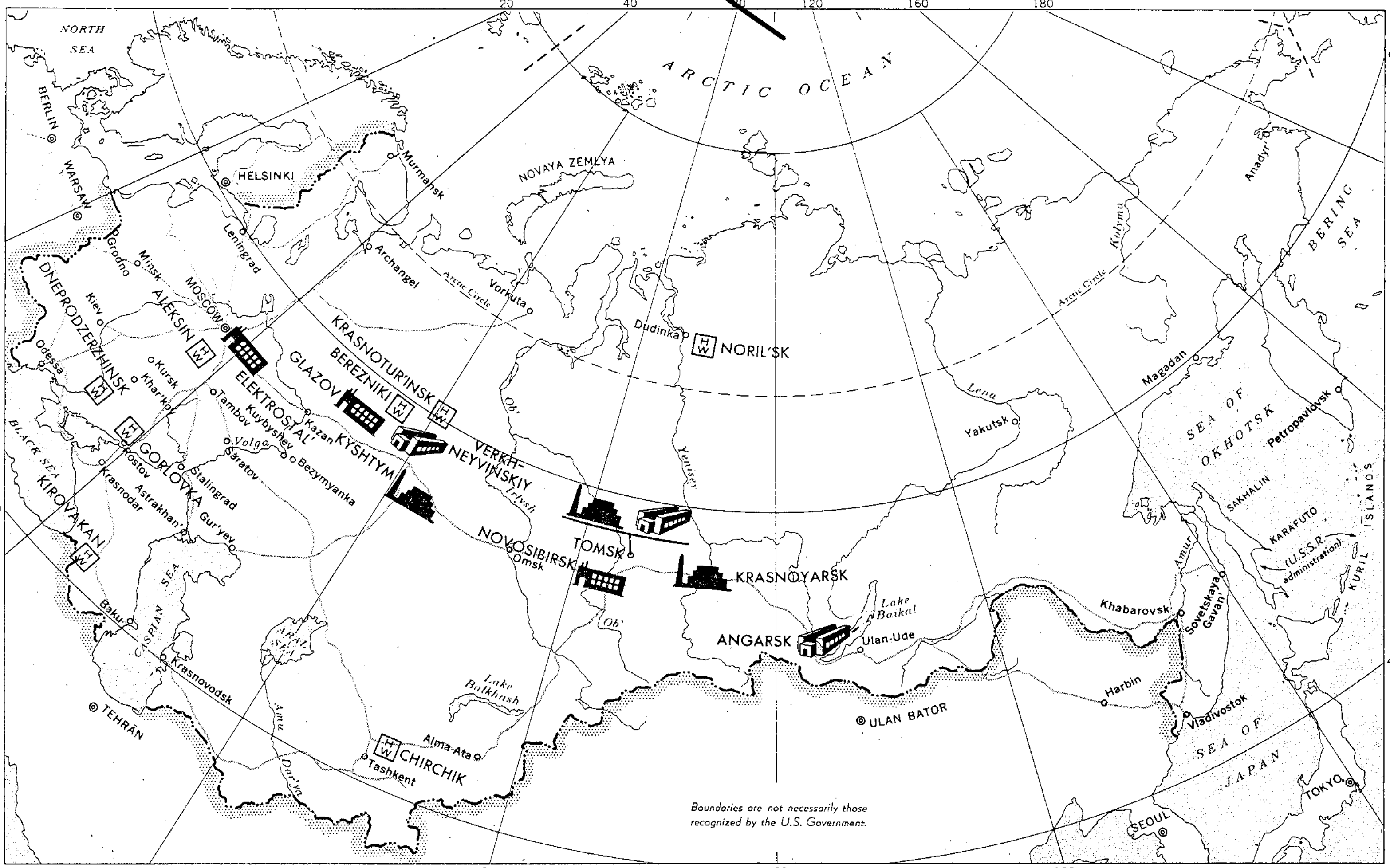
Figure 8



USSR
NUCLEAR MATERIALS PRODUCTION SITES

Plutonium

U-235

U-Metal

Heavy Water

0 250 500 1000 1500 2000
Statute Miles

0 250 500 1000 1500 2000
Kilometers

Railroad (selected)

~~SECRET~~

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b. The Tomsk plant started U–235 production around mid-1953 and expanded to a probable capacity of 6–8 kilograms per day in 1955. New plant construction was resumed at Tomsk in 1956 and will continue at least until 1960.

c. The Angarsk plant probably started operation during the first half of 1958. Atomic energy associated power expansions in the area indicate that its eventual capacity will be very large.

Basis for Estimating U–235 Production

110. Much is known from returned German scientists about the quality of the mesh-backed barrier used in the early Verkhneyvinsk gaseous diffusion cascades. This barrier was poor in both separating efficiency and pressure of operation, although these disadvantages were somewhat offset by its very high porosity. Good information was available on barrier manufacturing methods and production of the nickel wire mesh through 1953. Estimates of U–235 production on the basis of the quantity and quality of installed barrier are consistent, up to this time, with those based on power and efficiency calculations.

111. [redacted] For these reasons, post-1953 estimates are based upon power and efficiency calculations.

112. *U–235 Plant Efficiency.* A returned scientist reported that the Soviets used a target figure of 50 megawatt days per kilogram (MWD/Kg) as the efficiency for the gaseous diffusion cascade in early 1953 when it was compared with competitive systems. That the USSR could achieve this efficiency by 1953 is indicated by the information on the technical capabilities and known research and development work on gaseous diffusion technology. Operation at this efficiency is consistent with estimates of the electric power and barrier available at Verkhneyvinsk in this period. We estimate that after 1953 power utilization efficiency gradually improved, primarily as a result of improved compressor performance, which is in line with known Soviet technical achievements.

113. [redacted]

114. *Electric Power for U–235 Production.* The electric power supplied to Verkhneyvinsk can be closely estimated, first, on the basis of the transmission line network leading to the site, and second, on the net generating capacity feeding the network. There is a large body of information available on this subject, including voluminous data gleaned piecemeal from Soviet electric power publications. [redacted] have confirmed these analyses. Moreover, independent power balances over the entire Urals region, based on published statistics on unclassified consumers, indicate an unexplained surplus usage which corresponds with the Verkhneyvinsk estimate. Thus, the power supplied to Verkhneyvinsk can be estimated to the present within a cumulative error of plus or minus 20%.

115. The Tomsk gaseous diffusion plant is supplied by a large on-site thermal power plant now being augmented by both thermal and

nuclear power plant additions. Reliable information permits estimation of power at Tomsk within an accuracy equal to that of the Verkhneyvinsk power estimate.

116. Much less information is available on Angarsk power. An on-site power estimate believed to be reliable within plus or minus 50% has been made by combining generating capacity and transmission line information with power balances in Irkutsk Oblast and using power build-up rates comparable with those at Verkhneyvinsk and Tomsk.

117. Power actually used for U–235 production has been estimated by subtracting the power used for other site functions from the total power supplied. Except at Tomsk, the non-cascade power values must be assumed, but in any case they would be small compared with the total power available.

Related Economic Analysis

118. The U–235 estimates based on site information have been compared with independently derived estimates of uranium, fluorine, and nickel supplies available to the program, with estimates of ruble costs and expenditures, and with indications of economic motivation to improve or alter production operations. These independently derived estimates and conclusions indicate that budgetary allocations and required materials were certainly adequate for the demands of the program estimated herein, and in several cases appear to considerably exceed these demands. Moreover, the estimated U–235 production efficiency improves rather slowly in the light of economic incentive for improvement. In general, this economic intelligence research has shown that underestimation of U–235 production is more likely than overestimation.

Estimated U–235 Production

119. Estimated Soviet U–235 production is tabulated below (Table 9), together with the approximate electric power consumption values and average power utilization factors used in deriving it. The estimate has been prepared as follows:

Table 9

ESTIMATED SOVIET U–235 PRODUCTION [a] [18]

Mid-Year	[redacted]	Estimated Cumulative Production (KG 93% U–235) [b]
1950		[c] 25
1951		[c] 200
1952		700
1953		1,700
1954		3,900
1955		7,300
1956		12,500
1957		20,000
1958		29,000
1959		45,000
1960		67,000
1961		97,000
1962		135,000
1963		180,000
1964		225,000

[a] See paragraph 121, page 35 for the limits of uncertainty and validity of these values.

[b] Production of less highly enriched U–235 is included as equivalent quantities of 93% material.

[c] Production prior to mid-1951 was at enrichments below 93%. Presumably this material was later brought up to weapon grade.

a. *Mid-1949 – Mid-1953.* Early pilot plant information, electric power and plant efficiency estimates, [redacted]

b. *Mid-1953 – Mid-1959.* Electric power and plant efficiency estimates have been used.

c. *Mid-1959 – Mid-1961.* Electric power and plant efficiency estimates have been used, and the power estimate is based upon expansions of generation and transmission capacity now under construction in affected areas.

d. *Mid-1961 – Mid-1964.* Electric power and plant efficiency estimates have been used; however, efficiency estimates include

[18] See footnote 19, page 35, for the position of the Assistant Chief of Naval Operations for Intelligence, Department of the Navy.

the assumed incorporation of a much better barrier in new plant sections. Power estimates are based upon announced plans for expansion of generation and estimates of power usage for purposes other than atomic energy.

120. Assuming a continued expansion after mid-1964, the Soviets could have a cumulative U–235 production of about 600,000 kg of 93% U–235 by mid-1969. If the annual production remains constant after mid-1964, the cumulative production would reach about 450,000 kg by mid-1969. These estimates are very uncertain since actual production will depend on future Soviet policies and plans.

Margins of Error

121. Additional information has been obtained over the past year which increases our confidence in the U–235 estimate up to 1961. However, actual Soviet cumulative production up to that year could range between ±50% of the stated values.[19] A meaningful margin of error cannot be assigned after 1961.

PLUTONIUM EQUIVALENT PRODUCTION

Background

122. We have established the existence of Soviet plutonium production reactor sites in the Urals near Kyshtym and in central Siberia near Tomsk, and probably near Krasnoyarsk. Other sites may also exist, but none have been identified.

a. *Kyshtym.* Construction of the first Soviet production reactor started at Kyshtym in the Urals early in 1947, some six months before the first research reactor in the USSR went critical in Moscow. There is good evidence that this first Kyshtym reactor was graphite moderated and water cooled, fueled with about 100 tons of uranium, and operated between 100 and 200 thermal megawatts. Construction of a chemical separation plant for processing spent reactor fuel was completed a few months after the first reactor went critical. Other reactors have been built at Kyshtym but their construction schedule is unknown. Estimated uranium metal and heavy water availability and site timetables are consistent with the construction of about six reactors at Kyshtym by 1952, one or more of which were heavy water moderated. There is evidence of current continuing expansion at the Kyshtym site.

b. *Krasnoyarsk.* There is good evidence that a chemical separation plant was operating in the area of Krasnoyarsk in central Siberia by early 1955. Reactors to feed this plant probably went into operation around mid-1953. We believe that expansion at this site is currently under way.

c. *Tomsk.* The fissionable materials production site north of Tomsk is probably the location of the "Second USSR Atomic Power Station" described at the Second Geneva Conference on the Peaceful Uses of Atomic Energy. According to Soviet statements, the station will include six reactors, which we believe are dual purpose. One reactor went into operation in September 1958. The existence of an earlier reactor building without an associated power plant and the construction of a chemical separation plant have been reliably reported. The reactor building is believed to have started operation early in 1955. A third reactor building is now under construction at Tomsk with operation expected in the 1959–1960 period.

[19] In order to accept the estimate of cumulative production of U–235 (Table 9) the Assistant Chief of Naval Operations for Intelligence, Department of the Navy, finds that he would have to accept major factors of Soviet capability since 1953 which are in his opinion not sufficiently supported by available evidence. These factors include: (a) initial operation dates of new plants, (b) degree of enrichment and depletion of materials produced, (c) use of a new diffusion technology and new equipment, and (d) over-all plant efficiency. However, he believes that the assumption that an improved technology and improved plant efficiency have been developed and incorporated in new plants installed during 1953–1959 is consistent with known Soviet technological capabilities.

The Assistant Chief of Naval Operations for Intelligence, Department of the Navy, believes that the lower limits of the estimated values for the cumulative production of U–235 are the more nearly correct.

d. *Other Sites.* No other production reactor sites have been identified. However, the role of the possible atomic energy installation at Nizhnyaya Tura remains unknown. The large power plant near the old town probably exports about 500 EMW southward to the Nizhniy Tagil industrial complex and to the gaseous diffusion plant at Verkhneyvinsk. Thus, the Nizhnyaya Tura installation is not a U–235 plant, but may be, among other possibilities, a reactor site.

e. *Reactor Operating Practices.* Available evidence suggests that Soviet production reactor operations are conservative. [redacted] Moreover, analysis of the published pictures and information concerning the Tomsk dual purpose reactors indicates that these graphite moderated, water-cooled reactors with their 200 ton loading develop only about 500 to 700 thermal megawatts. This thermal power level represents an improvement in specific power level over the first production reactor by a factor of about two but is still far below the specific power that can be achieved with graphite-moderated water-cooled production reactors.

f. *Chemical Separation Processes.* Initially, the Soviets separated plutonium from uranium and fission products by an oxidation reduction, co-precipitation process. It was evidently planned to recover uranium as well as plutonium, since the uranium metal plant at Glazov was designed to process reactor-depleted uranium as partial feed material. However, this initial process apparently was unable to produce sufficiently decontaminated uranium. Soviet and German research on solvent extraction and other methods later resulted in better processes, [redacted] indicates that by late 1957 some uranium was being recovered successfully from plutonium separation plants and fed to gaseous diffusion plants.

Alternate Methods of Estimating Plutonium Production

[redacted]

[redacted]

124. *Materials Balance.* Information on production reactor construction and site expansion, particularly after 1953, is insufficient to permit use of reactor capacity as a basis for estimating plutonium equivalent production. Nevertheless, a measure of possible Soviet plutonium equivalent production can be obtained by converting to plutonium equivalent the excess of estimated amounts of uranium procured over non-reactor usage. Except for information on the form and size of any reserve stockpile of uranium that might be maintained by the Soviets, all the necessary additional data for such an estimate are either known or reasonably capable of being estimated; e.g., usage rates, flow patterns, pipeline lags, etc. [redacted]

125. *Economic Factors.* Economic studies indicate that there would have been economic incentives for the Soviets to have processed their above-ground uranium resources as fully as possible, at least after 1953. If a stockpile of uranium for emergency feed purposes were desired, they had strong incentives to increase their production of U–235 by operating their cascade at very high tails assays (.6 percent or above). Such a policy would have given them earlier production of a larger quantity of weapons grade U–235 at a lower unit cost and would still have afforded a readily accessible stockpile. Available intelligence establishes an ample capability to have followed this course. However, we have evidence that the tails assay of Soviet diffusion plants dropped between 1952 and 1958, indicating that the Soviets have not over-fed their U–235 plants. Therefore, the only way the Soviets could have made more intensive use of the uranium was by increasing plutonium and perhaps U–235 production either by more construction or by substantially improving the efficiency of existing plants. Assuming availability of reactor capacity, a full response to economic incentives would have resulted in a mid-1959 cumulative stockpile of plutonium equivalent about four times as great as that estimated by extrapolating on the basis of krypton measurements.

126. *Stockpiling Considerations.* The Soviets have maintained since 1931 large state reserves of a great many commodities on the basis of varying periods of future use of these commodities. Calculations for the period

prior to 1953, [redacted] indicate that the Soviets were probably consistently maintaining about a two-year stockpile of uranium throughout the period. Later reduction in stockpile levels is suggested by the increased feed requirements that would result from improved reactor power levels, by comparison of site construction activities with ore procurement rates, and by increasing response to economic motivations demonstrated in other parts of the atomic energy program in the post-1953 period. Complete elimination of the stockpile by mid-1959, however, would require more rapid construction and greater improvement to plants than are consistent with evidence of site construction activities, with estimates of electric power usage at reactor sites and with estimated production rates at uranium metal plants. In order to provide a basis of calculation yielding results which are consistent with this information, it is assumed in this estimate that uranium stockpiles decreased to an eighteen-month supply in the 1956–1958 period. It must be emphasized, however, that the supporting site data are rough estimates and that the particular stockpiling assumption used is unsupported by other quantitative intelligence.

Plutonium Equivalent Production Estimate

127. Several different plutonium production estimates were calculated using various uranium stockpiling assumptions. In the light of our best technical judgment, the set of production figures selected from these calculations represents the most likely Soviet plutonium equivalent production up to mid-1961 (Table 10, below). Soviet production from mid-1961 up to mid-1964 will be heavily dependent upon future Soviet plans and policies and may be influenced by unpredictable developments in weapons design. We have, however, presented figures for this period in Table 10 in order to provide general guidance to the planners.

Table 10

ESTIMATED SOVIET PRODUCTION OF NUCLEAR MATERIALS 1949–1964 [a] [20]

(Cumulative Amounts in Kilograms, Rounded)

	U–235 (93% Enriched) [b]		Plutonium Equivalent [d]	
Mid-Year	Estimated Production	Available for Weapon Usage	Estimated Production	[redacted]
1949	..	..	6	
1950	[c] 25	..	80	
1951	[c] 200	..	220	
1952	700	600	500	
1953	1,700	1,500	900	
1954	3,900	3,700	1,700	
1955	7,300	6,800	2,700	
1956	12,500	11,500	4,100	
1957	20,000	19,000	6,100	
1958	29,000	28,000	8,600	
1959	45,000	43,000	12,000	
1960	67,000	65,000	15,500	
1961	97,000	94,000	20,000	
1962	135,000	130,000	25,000	
1963	180,000	175,000	31,000	
1964	225,000	215,000	37,000	

[a] See paragraph 121, page 35, and paragraph 129, below for the limits of uncertainty and validity of these values.

[b] Production of less highly enriched U–235 is included as equivalent quantities of 93% material.

[c] Production prior to mid-1951 was at enrichments below 93%. Presumably this material was later brought up to weapon grade.

[d] Non-weapons uses of plutonium equivalent are expected to be negligible during the time period of this estimate.

128. If continued expansion after mid-1964 is assumed, the Soviets could have a cumulative plutonium equivalent production of about 95,000 kg by mid-1969. If the annual production remains constant after mid-1964, the cumulative production would reach 68,000 kg by mid-1969.

Margins of Error

129. Actual Soviet cumulative production of plutonium equivalent up to 1961 could range from about one-third stated values [redacted] to twice

[20] See footnote 21, page 39 for the position of the Assistant Chief of Naval Operations for Intelligence, Department of the Navy.

the stated values.[21] A meaningful margin of error cannot be assigned after 1961.

VII. THE SOVIET NUCLEAR WEAPONS PROGRAM

SOVIET PROVING GROUNDS

General

130. Three areas of the Soviet Union have been used more than once for the testing of nuclear devices: (a) the Semipalatinsk proving ground where at least 42 tests have been detected, (b) the Novaya Zemlya area where at least 20 thermonuclear and seven low-yield experiments have been detected, and (c) the general vicinity of the Kapustin Yar guided missile test range where air defense missile systems may have been tested on one, and possibly three occasions. One further low-yield nuclear test may have been held in this vicinity and probably was associated with the firing of a nominal 700 nautical mile ballistic missile. The locations of Soviet nuclear test areas are shown in Figure 9, and a list of all Soviet nuclear tests detected to date is presented in Table 12. Intelligence sources [redacted] indicate that the Soviet Union has conducted some nuclear tests of relatively low yield in addition to the reported 74.

The Novaya Zemlya Test Area

131. The Novaya Zemlya area was first used as a site for the testing of Soviet nuclear weapons in September 1955 when the first of a number of underwater, surface and low air-burst environmental effects tests was held off the southern end of the island. In September 1957, testing of thermonuclear devices began somewhat farther north (between 73° and 74° 30′ north latitude).

132. The assumed delivery aircraft for these operations, and possibly their crews, would logically have been acquired from Soviet bomber units which have been trained in nuclear delivery tactics. Logistic support probably also has been provided by the military, especially—considering the location—by the Soviet air forces and Navy. Technical direction of the test program itself undoubtedly has been exercised by the Ministry of Medium Machine Building.

133. *High-Yield Test Operations.* This area appears to have been selected for the full-scale testing of thermonuclear devices because of its remoteness, its very low population density, and its proximity to well-established mainland operational bases. Novaya Zemlya is not know to have any airfields capable of handling Soviet bombers such as the BADGER and BEAR; consequently, we believe that any aircraft employed in delivery operations are probably staged from bases on the nearby mainland.

134. So far as can be determined, no established proving ground, with elaborate instrumentation and support installations, has been created in the Novaya Zemlya area. [redacted] Weapons performance data requiring more elaborate instrumentation are probably acquired by airborne instrumentation and possibly by the radiochemical analysis of nuclear debris.

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[21] [redacted] In view of the above and the uncertainty of information as to the possible form and size of stockpiled uranium, as well as the uncertainty of information as to the input of uranium metal into production reactor operation, the Assistant Chief of Naval Operations for Intelligence, Department of the Navy, believes that the lower limit of the estimate, which is supported by the krypton data, represents the most probable value for plutonium production.

135. *Low-Yield Test Operations.* The Novaya Zemlya area was first used for low-yield nuclear tests on 21 September 1955 when JOE 17, a 6 KT device, was detonated under water at approximately 7036N, 5412E off the southern tip of the island. In succeeding years, in this general area, six more devices of comparatively low yield have been tested, consisting of at least one additional 10 KT underwater test, one test which detonated within one fireball radius of the surface, and four believed to have been air bursts. The yields of these underwater tests were derived from information released by the Soviet delegation to the Geneva Experts Conference. A member of the Soviet delegation also reported a 1 KT underwater test [redacted]

136. Except for JOE 17, the area around Novaya Zemlya has been closed because of "naval maneuvers" during those test periods when low-yield devices have been tested off the southern end of the island. While we have no confirmation that such maneuvers were undertaken, there can be little doubt that the underwater bursts represented tests of naval devices. Furthermore, the similarity in locations and yields leads us to believe that some of the airbursts in this same general area were probably in support of naval requirements—either to test the response of surface targets to nuclear effects or to develop naval nuclear warfare tactical doctrine.

137. The underwater tests were almost certainly designed to acquire basic hydrodynamic data on the response of naval targets to nuclear explosions in such environments.

The Semipalatinsk Proving Ground

138. The Semipalatinsk proving ground, constructed during the period 1947–1949, has been the principal area in the USSR for the testing of nuclear weapons. It is located in northeastern Kazakhstan, about 100 miles west of the city of Semipalatinsk. Forty-two of the 74 Soviet nuclear tests detected by the US have been held at this proving ground, which has a year-round capability and has been used for the full-scale testing of devices yielding up to 2.7 MT.

139. Major logistic support areas for the proving ground have not been identified. However, they must exist in the general area of the proving ground in order to insure adequate support for test operations.

140. Although the majority of Soviet tests detected at the Semipalatinsk proving ground [redacted] have been air bursts, [redacted] These tests have probably included the acquisition of diagnostic and basic blast effects data as well as comprehensive measurements of the response of equipment and structures to nuclear weapons effects.

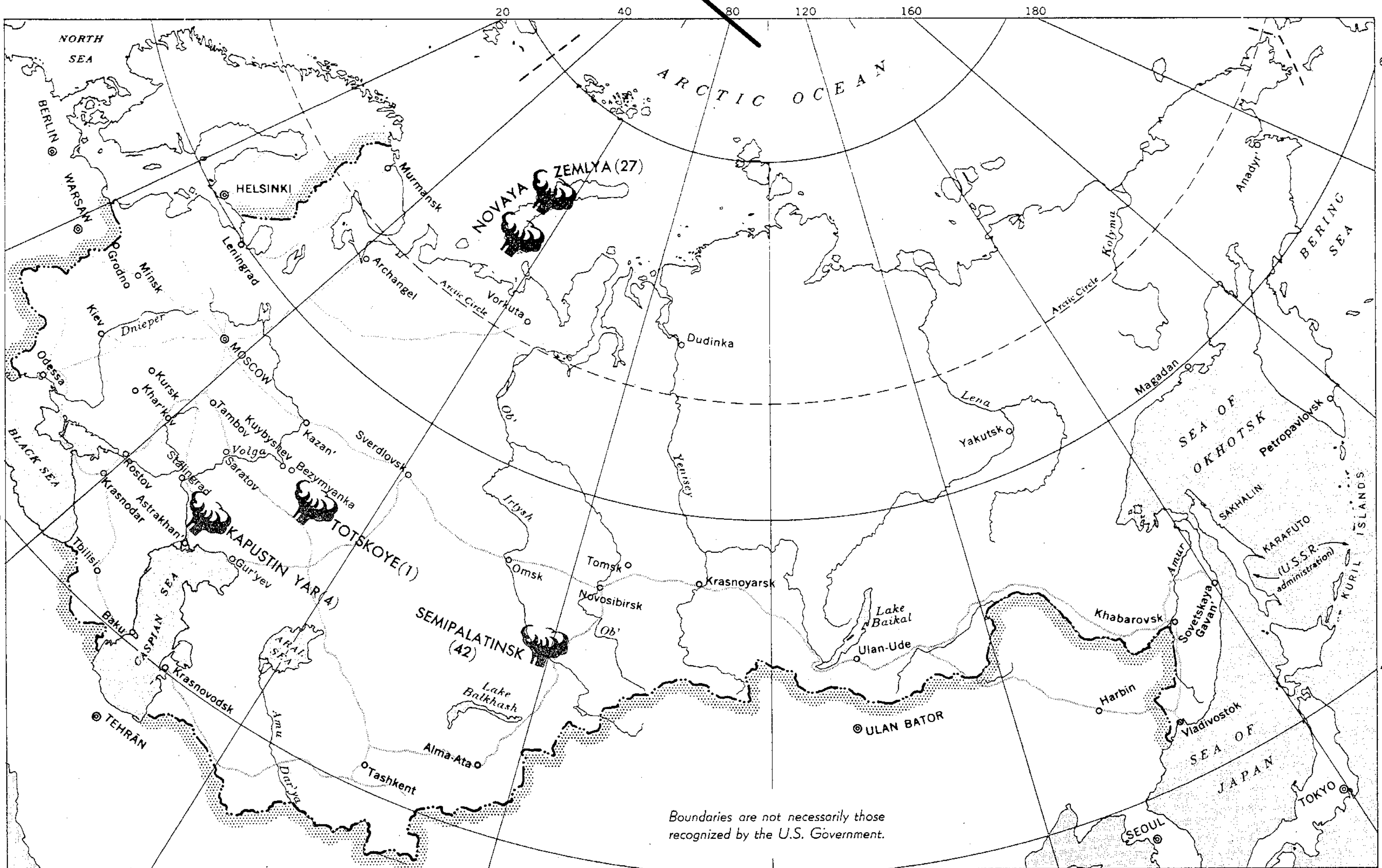
141. Because a large number of the test devices detonated occurred as air bursts at altitudes too great for accurate balloon suspension, we believe that ground instrumentation was limited. However, where tower shots are involved there presumably were heavily instrumented arrays for the acquisition of diagnostic data. Those experiments which have involved measurements of the response of equipment and structures to nuclear weapons effects would probably have included trenches and revetments for vehicles, tanks, artillery, aircraft, bridges, buildings and other structures.

Other Test Locations

142. The Soviet Union since 1953 has conducted at least five nuclear tests at locations other than the established testing areas at Semipalatinsk and Novaya Zemlya. These tests occurred at Totskoye (5231N, 5244E) on 14 September 1954; probably in the area north of the Aral Sea on 2 February 1956; and on 19 January 1957 and 1 and 3 November 1958, within an area northeast of the Kapustin Yar rangehead defined by 4900N, 4500E; 5100N, 4842E; 4942N, 5118E; and 4812N, 4736E.

143. *Totskoye.* The Totskoye army maneuvers and weapons effects test undoubtedly was designed both to test emerging Soviet Army nuclear warfare tactical doctrine and to provide a demonstration for officials of the Soviet Bloc and Communist Chinese military services. The test appears to have had a marked

Figure 9



USSR
NUCLEAR WEAPONS TEST AREAS

NUMBER DETECTED AT EACH AREA SHOWN IN PARENTHESIS

Statute Miles: 0 250 500 1000 1500 2000

Kilometers: 0 250 500 1000 1500 2000

Railroad (selected)

SECRET

27735 4-59

influence on Soviet military doctrine, resulting in changes in the recommended speed of deployment, grouping of forces, and the numbers and employment of atomic weapons under the control of a Front Commander. Some uncertainty exists regarding the type of weapon and delivery vehicle employed with the experiment. However, available intelligence indicates that this 35 KT to 100 KT device was air dropped.

144. *Kapustin Yar Area.* All nuclear tests conducted in the general area of the Kapustin Yar missile test range are believed to have been associated with missile delivery systems. However, in none of the four experiments outlined below do we have direct and unequivocal evidence of the specific types of missiles employed or the character of the test operations. It has been necessary, therefore, to infer the most probable nature and purpose of these tests from the characteristics of the warheads and from our knowledge of the state of the missile development program.

a. JOE 20 (2 February 1956). [redacted] We believe, on the basis of [redacted] radar intelligence on a missile firing on 2 February, that this nuclear test was probably associated with the firing of a nominal 700 nautical mile ballistic missile. Since analysis of the characteristics of the JOE 20 device indicates that it had a [redacted] yield much smaller than expected for the warhead in the Soviet 700 nautical mile surface-to-surface missile, we believe that the test most likely constituted a well-instrumented weapon system check-out utilizing a nuclear device of small mass and yield for range safety considerations.

b. JOE 29 (19 January 1957). As a result of new intelligence, this event is now believed to have involved the test of a missile nuclear warhead for use in an air defense system. Recent information related to the JOE 29 event includes:

(1) Re-evaluation of the probable altitude of the detonation. [redacted]

(2) The confirmation of a surface-to-air missile launching site [redacted]

(3) The statements by sources at the Geneva Conference of Experts in July 1958 that the Soviet Union had detonated a nuclear device yielding about 10 kilotons at an altitude of 10 kilometers (32,800 feet). None of the 55 Soviet tests detected up to the time of the statement fit exactly the yield and environment of the reported test. However, JOE 29 appears to be most nearly compatible with these data.

[redacted]

c. JOE 73 and 74 (1 and 3 November 1958). Within the limits of the errors of the available geophysical data, the test sites for these approximately 3 KT events probably were the same as that for JOE 29. [redacted] We believe that the choice of the location for JOE 73 and 74 was dictated by the vehicles employed rather than by the warheads and that the tests may have been associated with air defense missiles, either to acquire effects data or to test a nuclear weapon system. However, the possibility that other types of short range missiles may have been involved cannot be ruled out at this time.

In any case, the timing of the experiments after the opening of the political phase of the Geneva Conference on the Discontinuance of Nuclear Weapons Tests suggests that some priority was associated with them.

NUCLEAR WEAPONS TEST PROGRAM

Test Philosophy

145. Throughout the history of the Soviet nuclear weapons test program, there has been evidence of a willingness to accept certain risks and to forego the acquisition of substantial quantities of diagnostic data in order to achieve as rapid a pace of weapons development as Soviet scientific capabilities would allow. This philosophy has been exemplified by tests in which several weapons parameters were changed in a single experiment and by the use of aerial delivery for a large majority of the tests.

146. [redacted] A similar example occurred with JOE 19 (22 November 1955), which was an air drop [redacted]

147. More recently, continued Soviet application of this philosophy is apparent in the use of the Novaya Zemlya area for the full-scale testing of new designs of thermonuclear weapons. In this area we estimate that the Soviets probably place primary reliance upon airborne instrumentation.

148. Thirty-one of the 74 Soviet nuclear tests [redacted] were conducted during 1958. This effort represented a marked acceleration in the Soviet test program and was probably designed to exploit, in the face of a possible test ban, the several avenues of investigation which emerged from previous test series. The pace of testing was unusually intense, with the spring test series being conducted simultaneously in the Semipalatinsk and Novaya Zemlya areas and two tests per day being conducted on four occasions during the year.

149. The emphasis on aerial delivery throughout the Soviet program, though involving a sacrifice in the quantity and quality of purely diagnostic-type data acquired, has had the advantage of simplicity and has probably permitted the testing of a weaponized device with an associated delivery vehicle. The use of full-scale explosions probably has also permitted a check on the performance of a weaponized configuration of the device.

Test Instrumentation

150. With respect to the quantity and quality of instrumentation used, Soviet nuclear tests may be divided into three categories: (1) tower shots in which the tests are heavily instrumented and extensive diagnostic data are obtained; (2) air drops in which remotely placed ground instrumentation (and possibly some airborne instrumentation) is used and limited diagnostic data are obtained; (3) air drops in which airborne instrumentation is probably relied upon as a primary means of obtaining bomb performance data. [redacted] Test types (1) and (2) are conducted at the Semipalatinsk proving ground, and type (3) is conducted at the Novaya Zemlya proving ground.

151. The Soviets probably rely on their comparatively few tower shots for the acquisition of extensive diagnostic data. On the other hand, data obtained from the air-burst weapons are probably acquired primarily by ground or airborne fireball photography, [redacted] However, we estimate that sufficient data are acquired by this method to satisfy the basic requirements of the Soviet weapons development program.

152. Concurrently with their weapons evaluation and development program, the Soviets have carried on a weapons effects measurement program involving both basic physical measurements of blast, radiation and thermal intensities, and comprehensive measurements of the response of military equipment and structures placed at varying distances from the fireball.

153. Only a few basic effects tests, characterized by the use of yield-reliable stockpile devices and vehicle and structural target arrays, have been observed. These include at least two underwater tests and one test of an air-delivered device with which vehicle and structural target arrays have been associated.

Test Environments

154. Geophysical evidence indicates that of the 74 Soviet tests detected, at least 13 have detonated at heights of burst to achieve important blast and thermal effects (i.e., about two fireball radii), two in underwater environments, and at least eight within one fireball radius of the earth's surface. The two highest yield devices tested to date (JOE 66 and 70) were apparently detonated at the lowest altitudes consistent with prevention of significant fallout, and to maximize the fireball-to-delivery vehicle slant range. There is also evidence that the Soviets have detonated a limited number of devices on towers at the Semipalatinsk proving ground. On at least one (JOE 29) and possibly two other occasions (JOE 73 and 74), the Soviets may have conducted tests of nuclear warheads in an air-defense role.

155. No underground Soviet nuclear explosions have been identified. However, between mid-1956 and 1958 the Soviets conducted a series of massive (2 KT to 9 KT) subterranean high explosive detonations in the Soviet Union and Communist China in connection with construction projects and scientific experiments, which probably yielded a large amount of data on the feasibility of underground nuclear tests and the likelihood of concealing them from US detection. (See Table 11, Soviet Massive Underground Explosions.) The widespread publicity given these explosions and Soviet announcements of the planned use of such massive explosions with future construction projects could provide a cover for future concealed underground nuclear tests.

156. Of the 74 Soviet nuclear tests detected to date, none are believed to have been conducted at altitudes greater than 100,000 feet. We believe, however, that a considerable Soviet motivation for such tests must exist, and we would expect any future Soviet nuclear

Table 11

SOVIET MASSIVE UNDERGROUND EXPLOSIONS

Conventional High Explosives

Date	Location	Yield	Environment		Remarks
19 Jul 56	Lan'chou Province, China 3602N, 10250E	1.6 KT	Underground		To open ore mine.
Aug 56	Lan'chou Province, China 3602N, 10250E	3.1 KT	Underground		To open ore mine.
15 Nov 56	Lan'chou Province, China 3602N, 10250E	4.0 KT	Underground		To open ore mine.
31 Dec 56	Lan'chou Province, China 3602N, 10250E	9.2 KT	Underground		To open ore mine.
Unknown	China	15.0 KT	Unknown		Report believed invalid.
19 Dec 57	Tagansay, Uzbek SSR 4212N, 6851E	1.0 KT	129 feet Underground		Scientific experiment.
25 Mar 58	Pokrovsk-Ural'skiy 6006N, 5936E	3.1 KT	Underground		To open a water diversion channel.
1959	Padun Rapids on Angara River, 5154N, 10449E	30.0 KT	Underground		Proposed explosion.

test program to incorporate one or more nuclear experiments in very high altitude environments.

Droguing

157. The 1958 fall series of high-yield tests at Novaya Zemlya has been analyzed for evidence of Soviet use of parachute retardation, or other technique, to increase fireball-to-aircraft slant range. We estimate on the basis of the yield and height of burst of the device and on the estimated operational characteristics of current Soviet bomber aircraft, that on at least two occasions (JOE 66 and 70) droguing techniques must have been utilized to insure aircraft escape.

Test Failures

158. The Soviet test program has not been without its failures. [redacted] Available evidence further suggests that on at least one occasion (JOE 24—2.2 MT) the Soviets experienced either the failure of the fuzing system to detonate a test device at the desired altitude or the failure of device to perform as anticipated.

Device to Stockpile Lead Time

159. No direct evidence is available on the amount of time which elapses between the test of a Soviet nuclear device and its entrance into stockpile in weapons configuration. The extensive use by the Soviet Union of air delivery techniques, with the implication that the test devices are in ballistic configurations, indicates that the lead time currently is likely to be in the order of 12 to 18 months for devices bearing a high operational priority.

WEAPON DEVELOPMENT PROGRAM

Introduction

160. The Soviet nuclear weapon development program has grown rapidly, achieved great progress in weapons design, and included the test of a varied assortment of devices from which Soviet military planners can draw in meeting their requirements.

161. [redacted] Table 12 gives the chronology of the test program.

162. Preliminary analysis of the thirty-one Soviet tests conducted during 1958 provides fairly good insight into the emphasis accorded by the USSR to various nuclear weapons developments and the progress achieved. A concerted development effort continued on [redacted] thermonuclear devices, and yields up to 8 MT were achieved. [redacted] However, only slight progress in the fissionable material economy of high-yield weapons is apparent. [redacted] The Soviets further developed weapons yielding less than 10 KT, possibly for air defense or tactical use.

163. No direct information is available on the specific nuclear weapons types in the USSR stockpile. [redacted]

Table 12

EVALUATION OF SOVIET NUCLEAR TESTS

No.	Date	Location [1, 2]	Burst Height [4]	Yield (KT) [4]
1	29 Aug 49	Semi	Surface	20
2	24 Sep 51	Semi	Surface	30
3	18 Oct 51	Semi	Air	15
4	12 Aug 53	Semi	Surface	300
5	23 Aug 53	Semi	Air	25
6	3 Sep 53	Semi	Air	8
7	10 Sep 53	Semi	Air	8
8	14 Sep 54	Totskoye 53.1N, 51.9E	$\frac{1,000}{1,500}$	$\frac{35}{100}$
9	3 Oct 54	Semi	Air	4
10	5 Oct 54	Semi	Air	45
11	8 Oct 54	Semi	few 1,000	[7] <20
12	23 Oct 54	Semi	Air	90
13	26 Oct 54	Semi	Air	7
14	30 Oct 54	Semi	Air	25
15	29 Jul 55	Semi	Surface	4
16	2 Aug 55	Semi	Air	30

See footnotes at end of table.

Table 12 (Continued)

No.	Date	Location [1, 2]	Burst Height [4]	Yield (KT) [4]
17	21 Sep 55	NZ 70.6N, 54.2E	Underwater	6
18	6 Nov 55	Semi	3,500	200
19	22 Nov 55	Semi	4,500	1,600
20	2 Feb 56	Caspian Sea	Air	6
21	16 Mar 56	Semi	Surface	30
22	25 Mar 56	Semi	Surface	25
23	24 Aug 56	Semi	Tower	60
24	30 Aug 56	Semi	3,300	2,200
25	2 Sep 56	Semi	>1,500	100
26	10 Sep 56	Semi	1,500 / 3,000	90
27	17 Nov 56	Semi	7,800	2,700
28	14 Dec 56	Semi	Air	50

See footnotes at end of table.

29	19 Jan 57	Kapustin Yar, 49.5N, 48.0E	Air	7
30	8 Mar 57	Semi	Air	15
31	3 Apr 57	Semi	Air	70
32	6 Apr 57	Semi	Air	70
33	10 Apr 57	Semi	6,800	1,300
34	12 Apr 57	Semi	Air	30
35	16 Apr 57	Semi	$\frac{5,000}{7,000}$	750
36	22 Aug 57	Semi	2,000	500
37	7 Sep 57	NZ 7036N, 5412E	Surface	25
38	13 Sep 57	Semi	Unk	<20
39	24 Sep 57	NZ 7348N, 5524E	$\frac{7,000}{10,000}$	3,200
40	26 Sep 57	Semi	Air	8
41	6 Oct 57	NZ 7348N, 5500E	6,500	4,300

See footnotes at end of table.

Table 12 (*Continued*)

No.	Date	Location [1, 2]	Burst Height [4]	Yield (KT) [4]
42	10 Oct 57	NZ 7036N, 5412E	Underwater	10
43	28 Dec 57	Semi	Air	7
44	4 Jan 58	Semi	Unk	1.5 3
45	17 Jan 58	Semi	Unk	<5
46	23 Feb 58	NZ 7418N, 5348E	10,500	1,200
47	27 Feb 58	NZ 7418N, 5400E	10,300	2,500
48	27 Feb 58	NZ 7424N, 5336E	10,800	520
49	13 Mar 58	Semi	Air	<10
50	14 Mar 58	NZ 7415N, 5420E	Air	30
51	14 Mar 58	Semi	Air	30
52	15 Mar 58	Semi	Air	10
53	20 Mar 58	Semi	Air	15
54	21 Mar 58	NZ 7400N, 6000E	$<7,500$	1,000

See footnotes at end of table.

55	22 Mar 58	Semi	Unk	20
56	30 Sep 58	NZ 7345N, 5445E	6,800	1,200
57	30 Sep 58	NZ 7324N, 5500E	8,500	2,100
58	2 Oct 58	NZ 7345N, 5430E	Air	350
59	2 Oct 58	NZ 7338N, 5730E	Air	50
60	4 Oct 58	NZ 7037N, 5445E	Air	5
61	5 Oct 58	NZ 7037N, 5445E	Air	25
62	6 Oct 58	NZ 7042N, 5455E	Air	2.5
63	10 Oct 58	NZ 7338N, 5415E	Air	200
64	12 Oct 58	NZ 7330N, 5500E	5,400	2,100
65	15 Oct 58	NZ 7400N, 5500E	7,600	3,000
66	18 Oct 58	NZ 7400N, 5400E	7,800	7,600 3
67	19 Oct 58	NZ 7350N, 5735E	Air	5
68	20 Oct 58	NZ 7335N, 5418E	Air	400
69	21 Oct 58	NZ 7038N, 5445E	Air (?)	<5
70	22 Oct 58	NZ 7400N, 5500E	7,300	6,100
71	24 Oct 58	NZ 7400N, 5800E	7,600	2,200
72	25 Oct 58	NZ 7400N, 5800E	Air	200

See footnotes at end of table.

Table 12 *(Continued)*

No.	Date	Location [1, 2]	Burst Height [4]	Yield (KT) [4]	
73	1 Nov 58	Kapustin Yar 4930N, 4800E	Air (?)	3.5	[redacted]
74	3 Nov 58	Kapustin Yar 4930N, 4800E	Air (?)	3	

[1] Semi—Semipalatinsk.

[2] NZ—Novaya Zemlya.

[redacted]

[4] Values of burst height and yield are best values.

[redacted]

[6] Where a range of values have been reported, they are written as minimum/maximum.

[7] Greater than: >; less than: <; approximately: ~.

[redacted]

164. [redacted]

Nuclear Weapons Capabilities, 1958–1963

165. We estimate that during 1959 the Soviets have the capability to produce thermonuclear weapons in the following yield and weight classes:

[redacted] While we believe they have the technical capability to develop large weapons in this yield range, we would expect them to have conducted tests of full scale or reduced yield versions if they had a requirement for such weapons. In view of the absence of any such tests during the extensive series in 1958, we estimate that the Soviets [redacted] do not have a strong present requirement for weapons in this yield range.

167. We estimate that during 1959 the Soviets have the capability to produce fission weapons in a variety of types and yields, [redacted] yielding 100 KT, [redacted]

168. During the period 1960–1963, if no further testing occurs, the above current capabilities in fission and thermonuclear weapons could be only slightly improved. If unlimited tests are conducted, we estimate that the major improvement will be shown in thermonuclear devices. In particular, we would expect increases in fissionable material economy and in yield-to-mass ratios [redacted] Also, we believe that the Soviets will [redacted] develop very low-yield devices and, if the requirement exists, increase the yield in some of the available weapon weight categories at the expense of additional fissionable material. With these exceptions, we do not expect the estimated current designs of fission weapons to be improved greatly during the period of this estimate.

Nuclear Weapons Capabilities, Post-1963

169. In the post-1963 period, we do not expect the advancement of Soviet nuclear weapon development to be as rapid as in the past, since we believe that they have reached a state of the art where major improvements in performance are difficult to achieve. Assuming unlimited testing, we estimate that the USSR will be capable of producing nuclear weapons in the range of yields and characteristics required for support of major anticipated Soviet military requirements. [redacted]

Table 1

ESTIMATED SOVIET THERMONUCLEAR WEAPON DEVELOPMENT POTENTIAL

(Based on estimated current Soviet capabilities, using US developments as a guide)
(Potential improvements indicated for the 1961–63 period are based on unlimited testing)

Number	Approx. Diam. (in)	Approx. Weight Class (lbs) (Reasonably attainable minimum weights) Bomb Class	Approx. Amounts of Nuclear Materials U-235	Approx. Yield (MT) 1957–58	1959	1960	1961	1962	1963
TN-1	35	12,000							
TN-2 [b]	50	[b] 11,000							
TN-3A [c]	35	6,500							
TN-3B	..	..							
TN-3C	..	..							
TN-4A [c]	35	5,500							
TN-4B [c]	..	..							
TN-5A	30	5,500							
TN-5B	..	..							
TN-5C	..	..							
TN-6A [c]	30	4,500							
TN-6B	..	..							
TN-6C	..	..							
TN-7A	30	3,500							
TN-7B	..	..							
TN-8A [c]	24	2,500							
TN-8B [c]	..	..							
TN-8C	..	..							
TN-9A [c]	22	2,000							
TN-9B	..	..							
TN-9C	..	..							
TN-10A [c]	18	1,300							
TN-10B	..	..							

[a] Includes fuzing and firing system, but not ballistic case or nose cone.
[b] These weapons would require at least one test in either full-scale or reduced-yield configurations before stockpiling on other than an emergency basis.
[c] Based on analysis of specific Soviet tests.
[d] Based on Soviet tests conducted in 1958 and would not be available in stockpile in 1959 except in limited quantities (10 to 50 weapons).

Table 2

ESTIMATED SOVIET FISSION WEAPON DEVELOPMENT POTENTIAL

(Based on estimated current Soviet capabilities, using US developments as a guide)
(See footnote [b] *re* estimated future fission weapons development capabilities)

Number	Approx. Diam. (in)	Approx. Weight Class (lbs) (Reasonably attainable minimum weights) Bomb Class	Approx. Amounts of Nuclear Materials U-235	Approx. Yield (KT) 1957–58	1959	1960–63
F-1	18	350				
F-2A [c]	45	3, 500				
F-2B [c]	..	..				
F-3A [c]	30	1, 200				
F-3B [c]	..	..				
F-4 [c]	25	1, 000				
F-5A [c]	20	700				
F-5B [c]	..	..				
F-5C [c]	..	..				
F-6 [c]	20	450				
F-7A [c]	18	300				
F-7B	..	..				
F-7C	..	..				
F-7D [c]	..	..				
F-7E [c]	..	..				
F-7F	..	..				
F-8 [c]	16	350				
F-9	10	450				
F-10A	8	250				
F-10B	..	..				

[a] Includes fuzing and firing system, but not ballistic case or nose cone.

[b] Assuming continued testing, we believe only slight improvement will be made in these weapon categories and we estimate that the above 1959 Soviet fission weapons development potential adequately reflects their capabilities for the period 1959–1963. See paragraphs 179 and 181 in text for discussion of extremely light-weight devices and gun-assembly weapons.

[c] Based on analysis of specific Soviet tests.

[d] Based on Soviet tests conducted in 1958 and would not be available in stockpile in 1959 except in limited quantities (50 to 100 weapons).

[redacted]

170. In addition to thermonuclear weapons, a wide variety of fission weapons, including very small low-yield weapons, will be available to meet various requirements. [redacted] however, no valid prediction can be made on the timing of such developments.

Current Trends

171. Analysis of the 1958 test program indicates that the Soviets are continuing their intensive development of [redacted] thermonuclear weapons in a wide range of yields and weights suitable for both air and missile delivery. For the first time, yields up to 8 megatons were achieved [redacted] (JOE 66 and 70). Five tests of thermonuclear devices yielding 2 to 3 MT indicate strong emphasis on development of weapons [redacted]

172. [redacted]

173. Eight of the 31 devices tested during 1958 yielded less than 10 KT. Some of these devices appear to have been small in size [redacted] probably represent the development of air-defense or tactical weapons.

174. [redacted]

Weapon Development by Type

175. *Thermonuclear Devices*

a. The Soviet weapon tests have shown a strong emphasis on thermonuclear weapons since November 1955. About 40% of the total tests detected to date have been either full-scale thermonuclear devices or experimental devices associated with thermonuclear development. In the 19 tests conducted during the fall of 1958, at least 11 of the devices were thermonuclear in nature.

b. [redacted]

c. During the fall of 1958, the Soviets tested what is apparently a new class of thermonuclear weapons. JOE 58 and 63, yielding 350 and 200 KT, [redacted]

d. The test of five TN devices during 1958 yielding 2–3 MT indicates strong emphasis on a weight class [redacted]

e. [redacted]

[redacted]

176. *Fission Devices.* We have reasonable confidence in our estimate of fission weapon developments for yields greater than 10 KT. However, information on lower yield Soviet tests is very limited, and our estimate of Soviet capability in yield ranges of 1 to 10 KT is much less complete.

a. [redacted]

[redacted]

177. [redacted]

181. *Gun-Assembly Weapons.* Although the USSR is not known to have tested nuclear weapons employing gun-type assembly, it is considered that, because of the simplicity of design, weapons of this type could now be available in stockpile. These weapons would, however, require large amounts of fissionable materials. Therefore, we estimate that if the Soviets stockpile gun assembly weapons at all, they would stockpile only small quantities of these weapons. One possible version of this weapon, suitable for artillery shell applica-

tions, would be eight inches in diameter, weight about 250 pounds, [redacted]

Requirements In Future Tests

182. If more tests are conducted, we estimate that future Soviet tests would be primarily directed toward achieving a greater yield-to-mass ratio in all classes of thermonuclear designs, a continued reduction in weight and diameter for thermonuclear devices, and an effort to increase the economy of fissionable materials.

183. In addition, should Soviet military policy require, we would expect tests of devices yielding in the order of 20 MT and greater, although a Soviet interest in such devices has not been demonstrated to date. However, the development of such high-yield devices might be achieved by the testing of reduced yield configurations, thereby avoiding the need for very high-yield tests.

184. We estimate that the Soviets will continue to develop and test low and very low-yield, small-size weapons. We also estimate a Soviet requirement for effects tests in rarified atmosphere, i.e., 100,000 feet or higher.

STOCKPILING OF NUCLEAR WEAPONS

General

185. The availability of fissionable materials for weapons uses and the progress of the weapon and vehicle development programs indicate that there was no need for an extensive dispersed storage program until after 1953. During this early period we believe that assembly and storage of Soviet weapons were conducted at a weapon design and fabrication facility which is probably in the Sarova area [redacted]

186. We believe, however, that extensive long-range plans for a dispersed assembly and storage system were already underway at least as early as 1952. The development and implementation of these long-range plans have been closely integrated with the growth of Soviet nuclear weapon production capacity, and the design and construction of the physical facilities have paralleled specific requirements emerging from developing nuclear weapon designs.

187. We believe that at least three national assembly and stockpile sites, which possibly are operated by the Ministry of Medium Machine Building, are the central part of the Soviet nuclear weapons logistics system and are designed to supply weapons for all types of military nuclear delivery systems.

188. Our knowledge of the location and nature of storage facilities available to the military is confined principally to two types of operational storage sites located at airfields of Long Range Aviation. We estimate that, in addition to these sites, facilities for nuclear weapons storage exist at several naval airfields and airfields of the Tactical Aviation. Although no nuclear weapon storage facilities have been identified at naval surface facilities or co-located with ground force units, we believe that appropriate storage facilities for them probably exist. [redacted]

National Assembly and Stockpile Sites

189. We believe that the first of the national stockpile sites were probably designed and under construction in the period 1952–1954. It is likely that the location of these sites is based on geographical and military considerations so that they can serve all armed forces operational storage sites located in a specific area. [redacted] The national sites probably contain facilities to assemble the weapon to stockpile configuration. In addition, they probably also have facilities to store the weapons and to ship them to the operational storage sites.

Regional or Forward Storage Sites

190. At least two additional nuclear weapons storage facilities, which may be regional or forward storage sites, are believed to exist [redacted]

Operational Nuclear Storage at Airfields

191. During late 1953 and through 1954, site preparation and construction of the first of the Soviet dispersed operational storage facilities probably began. [redacted]

Other Operational Storage Facilities

194. We have very limited intelligence on operational storage facilities other than those at airfields. Nuclear weapons storage facilities specifically associated with units of the Soviet ground forces and navy have not been identified. However, nuclear tests specifically oriented to the requirements of these services, tactical nuclear exercises conducted since late 1953, and the development and dissemination of army nuclear warfare tactical doctrine in 1954–55 all indicate that such facilities must certainly exist. In the present time period it is not considered likely that the Soviets have elected to store nuclear weapons outside the borders of the USSR, although the capability to deploy them rapidly to Soviet forces in such areas certainly exists.

SOVIET ATOMIC ENERGY DETECTION SYSTEM

General

195. In the period 1953–54, the Soviet Union organized a foreign nuclear test data collection system involving seismic, acoustic, electromagnetic, and probably debris collection elements. Soviet capabilities in geophysical detection techniques are believed to be reasonably good but not comparable to those of the US.

196. The Soviet data collection system on foreign nuclear tests consists of at least four elements: seismic, acoustic, electromagnetic and debris collection. These techniques are believed to have been within Soviet capability as early as 1953–54, but confirmation of the employment of all four techniques was lacking until the Conference of Experts at Geneva in July and August 1958. The Geneva Conference also offered a unique opportunity for evaluating the system and the men who appeared to be responsible for its operations. Super-

vision of the various elements appears to be divided, with geophysical activities probably under the leadership of M. A. Sadovskiy and debris collection under another, as yet undetermined, director.

Debris Collection Program

197. The Soviets attending the Geneva Conference of Experts confirmed the existence of a debris collection activity by the USSR, but failed to indicate its subordination. Of the Soviet delegation, only N. N. Semenov, Director of the Institute of Chemical Physics, Academy of Sciences, and Genady Kirdin, from the Institute of Applied Geophysics, Academy of Sciences, appeared to be knowledgeable on the subject of debris collection and analysis.

198. Specifically, the Soviets acknowledged that they had employed airborne collection in the past, but stated they had since changed over to a ground system of 150 collection stations employing air filtering devices as well as passive debris collection on plates and rain water. They claimed that these techniques were fully as effective as the airborne filtering and less expensive to operate. Although the political motivations behind the Soviet desire for a ground collection component in an international inspection system are understandable, the reasons for their apparent abandonment of airborne collection for intelligence purposes remain obscure.

199. The Soviet delegates at Geneva avoided the subject of radiochemical analysis of debris. However, since radiochemical identification and dating have been mentioned in Soviet literature, there can be little doubt that they are aware of the principles involved and have probably made use of at least the basic techniques. They appeared impressed by the information Western scientists had obtained from their analysis, and it appears probable that the potentialities of radiochemical analysis to obtain information on weapons design have not been exploited in the USSR to the extent that they have been in the US and UK.

The Seismic Element

200. The seismic element of the data collection system is under the direction of Ivan Petrovich Pasechnik, of the Institute of Physics of the Earth, Academy of Sciences, Moscow. The network of Soviet stations provides facilities at the east-west geographic extremes of the USSR, while two stations set up for the International Geophysical Year at Mirnyy and Oazis in the Antarctic, which began operation in 1957 and 1958 respectively, could provide the Soviet Union with information on UK tests in Australia, an area to which their domestic stations are denied access for geographical reasons.

201. Data presented by the Soviet delegation at the Geneva Conference of Experts revealed that the USSR employs throughout its network of stations high quality seismic equipment. Discussions revealed, however, that the Soviets lacked experience in differentiating explosions from natural seismic events, a fact which would lower their capability to detect and identify underground nuclear explosions, especially in the lower yield ranges.

The Acoustic Element

202. Confirmation of Soviet use of acoustic techniques was acquired at the Geneva Conference of Experts. The Soviets at Geneva stated that ten stations were in operation at the end of March 1956, and it appears probable that some, if not all, are co-located with seismic stations.

203. Of the delegates present at the Conference, K. I. Balashov appeared to be responsible for the operation of the Soviet acoustic network, with K. E. Gubkin connected with its theoretical and analytical aspects, and L. M. Brekhovskikh acting as an advisor.

204. In general, the Soviet experts appeared to have worked with less data than had their Western counterparts. They displayed a tendency to draw conclusions more from theoretical calculations than from experience, but claimed to have detected nuclear tests acoustically from a distance of 3500 kilometers.

Electromagnetic Element

205. As in the case of the acoustic element, the existence of a Soviet electromagnetic (radio wave) activity was not verified until the Geneva Conference, although it had been recognized to be well within the capability of the USSR. Of the Soviet Conference delegates, Aleksandr Ustyumenko appeared to be in charge of the Soviet electromagnetic element, with L. M. Brekhovskikh probably acting as an advisor.

206. Soviet discussions of the subject both in the conference sessions and in private conversations indicated that Soviet work in the electromagnetic field had been vigorously pursued, and their techniques may well be more advanced than those of the West. In particular, the Soviets advanced new theoretical methods for discriminating natural and man-made electromagnetic disturbances. They further implied that work was in progress on developing some type of automatic discriminator for the screening and identification of these signals.

VIII. POSSIBLE SOVIET ALLOCATIONS OF FISSIONABLE MATERIALS TO WEAPONS STOCKPILES. 1959–1962 [23, 24, 25]

INTRODUCTION

207. We lack sufficient evidence to support a firm estimate of the Soviet weapons stockpile by number, by type, by mission, or otherwise. Accordingly we rely on the following general factors:

a. Our assessments of over-all Soviet military policy, and of Soviet strategy for general and limited war, derived from our basic Soviet estimate, NIE 11–4–58, (Main Trends in Soviet Capabilities and Policies 1958–1963, 23 December 1958);

b. Estimates of the types of weapons tested by the Soviets and of relative Soviet emphasis on missions and weapons systems that might employ nuclear weapons wholly or in part.

208. With these factors as general guides, more specific factors bearing on weapons stockpile allocations at any selected period are:

a. Our specific estimates of Soviet development, and in some cases production, of delivery systems in which a high proportion of delivery vehicles must be equipped with nuclear weapons in order to perform the designated missions with acceptable effectiveness;

b. Target studies of the major target systems against which the Soviets would probably seek to employ nuclear weapons offensively;

c. Assessment of technical factors, notably the balance of available fissionable materials (as between U–235 and plutonium-

[23] This Section supersedes the Supplement to NIE 11–2–58, "Possible Soviet Allocations of Fissionable Material to Weapons Stockpiles, 1958–1962," approved 30 September 1958. (Referred to hereinafter as the "1958 Supplement.")

[24] The Assistant Chief of Naval Operations for Intelligence, Department of the Navy, believes that the range of possible Soviet quantitative allocations to weapons stockpiles is so broad that, in view of the status of available intelligence on this subject (as indicated in paragraph 207) an estimate of "possible allocations" is unrealistic and of doubtful usefulness. Therefore he does not concur with the general methodology employed to derive this section or with the illustrative allocations (Tables 13 and 14).

[25] The Assistant Chief of Staff for Intelligence, Department of the Army, does not concur with the methodology employed to derive this section or with the "illustrative allocations" (Tables 13 and 14). In view of the insufficiency of evidence on this subject (as indicated in paragraph 207), he considers that the "illustrative allocations" are merely highly speculative possibilities selected arbitrarily from an almost infinite number of alternative choices. At best such theorizing from unsupported conjectures is unrealistic and of doubtful value; it creates a high risk of inadvertent misuse, for example, in briefings for budgetary or planning purposes, leading to the danger of miscalculation by those responsible for national security.
The Assistant Chief of Staff for Intelligence, Department of the Army believes that, on the basis of available intelligence, the most definitive presentation that can be made of the availability of nuclear weapons in the Soviet stockpile is one indicating a broad range of technological possibilities as shown graphically in figure 11, page 66.

equivalent), production rate and retrofit[26] problems, and the degree of interchangeability of weapons assemblies for various uses;

d. Intelligence information on stockpiling practices and doctrine for the use of nuclear weapons for various purposes.

THE SOVIET WEAPONS DEVELOPMENT PROGRAM IN RELATION TO MISSIONS AND WEAPONS SYSTEMS

209. The Soviet test program over the years since its inception has shown the development of nuclear weapons to meet a wide variety of military requirements, including all the major categories of need—long-range bomber weapons, warheads for long- and intermediate-range guided missiles, air defense, support of naval and ground operations, and naval employment. In comparison with the US development program, the Soviets have not shown a clear interest in extremely low-yield (less than 1 KT) tactical weapons (on which, however, it is possible that tests would not have been detected), very high-yield weapons (greater than 10 MT) and, with one possible exception, "clean" weapons. Our estimate of the various weapons types reflects these omissions.

Planned Long Range Aviation Employment[27]

210. Soviet emphasis on the development of Long Range Aviation (LRA) throughout the post-war period has indicated great interest in strengthening their capabilities in this field. While early medium-yield weapons[28] probably were an interim armament for such a force, the Soviets clearly laid heavy stress on the rapid development and continued refinement of thermonuclear weapons suitable for bomber delivery. Confirmation of on-base nuclear weapons storage sites at long and medium range bomber bases demonstrates extensive preparations for deployment and suggests that nuclear weapons are now widely deployed to Long Range Aviation forces. We believe the Soviets will seek to provide nuclear weapons for all LRA bombers intended to be used for weapons delivery in the event of general war.

Planned Long-Range and Intermediate Range Guided Missiles Employment

211. There is good evidence that the Soviets have given a very high priority to the development of land-based surface-to-surface missiles having ranges of about 700 n.m., 1100 n.m., and 5500 n.m. We also believe that the Soviets have developed submarine-launched surface-to-surface missiles. In the light of our estimate of the accuracy of all these missiles, their most effective use would clearly be with high-yield thermonuclear weapons, and Soviet emphasis on such weapons is confirmed by the nature of the 1957–58 Soviet test program, plus Soviet public statements. Accordingly, we believe that thermonuclear warheads are being, and will be, produced in numbers sufficient to equip all missiles intended for operational use in the 1100 and 5500 n.m. categories, and substantially all in the 700 n.m. category.

Planned Air Defense Employment

212. The Soviets have placed strong emphasis on air defense, and have developed surface-to-air missiles now deployed in large numbers in Moscow and possibly in a few other key areas, with advanced types probably under urgent development. We believe that these missiles were originally designed to be equipped with HE warheads but that nuclear warheads are adaptable to some models and that the Soviets would seek to furnish such warheads for some proportion of these at the earliest practical date. Four to six Soviet nuclear tests appear to be related to the development of air defense warheads or to warhead applications in air defense systems. We

[26] Retrofit is defined as the modernization of atomic weapons and components, and related equipment, by applying changes in design and fabrication to stockpile weapons.

[27] See NIE 11-7-58, "Strength and Composition of the Soviet Long Range Bomber Force," dated 5 June 1958.

[28] As used in this estimate, the term high-yield weapons includes all yields greater than 100 KT, medium-yield weapons includes yields from 25–100 KT, and low-yield weapons includes yields less than 25 KT.

estimate that in 1959 the Soviets will allocate nuclear warheads to surface-to-air missiles.

Planned Employment in Support of Ground Operations

213. Since 1954 considerable reliable evidence on current Soviet army doctrine has revealed that the use of nuclear weapons in support of ground operations is contemplated. This doctrine also visualizes delivery of nuclear weapons by a variety of methods, including rifled artillery, free rockets, missiles, and aircraft. Intelligence on Soviet training continues to indicate the planned employment of tactical nuclear weapons by Soviet forces. In September 1954 the Soviets conducted an air drop at Totskoye of an estimated 35 to 100 KT weapon in connection with Army maneuvers and a military effects test. This demonstration before communist Bloc military leaders was clearly associated with the development of nuclear warfare tactical doctrine. A Swedish military delegation which visited the USSR in November 1958 was told that the Soviet army has in its arsenal 2 KT atomic shells, 5 KT rocket warheads, and 10, 20, and 50 KT tactical bombs. Furthermore, there is some evidence that nuclear weapons storage areas may be located adjacent to certain tactical airfields. Eight of the 31 devices tested during 1958 were less than 10 KT in yield. Some, by their small size and economy of fissionable material, probably represented the development of air defense or tactical weapons. We do not believe that the present Soviet fissionable material stockpile permits the use of very large numbers of low-yield nuclear weapons for tactical uses along with substantial numbers of high-yield weapons. However, within the next two years presently estimated rates of production of fissionable materials will permit the Soviets to afford large numbers (in the thousands) of tactical weapons.

Planned Naval Employment

214. During recent years, statements by Soviet political leaders and senior naval officers have stressed the naval warfare requirements of the USSR in general war, limited war, or cold war, and have both stated and implied the necessity for possessing nuclear weapons to wage present-day naval warfare. We believe that certain naval aircraft units have been designated for nuclear delivery roles, including the use of air-to-surface missiles. Moreover, we estimate that the Soviets will convert a limited number of existing submarines for missile delivery and will probably also construct new submarines specifically designed for this purpose. Of the weapons tested by the USSR, a number of medium and low-yield weapons types would be suitable for use against naval targets. In addition, evidence of naval concern for nuclear weapons has been provided by tests conducted in northern waters off Novaya Zemlya, once in 1955 (under water) and twice in the fall of 1957 (one under water, one air burst), which almost certainly were related to naval effects. Four additional tests during the fall of 1958 were conducted at the south end of Novaya Zemlya and may have had naval associations. In addition, the Soviets, at the Geneva Experts Conference during the summer of 1958, alluded to a third underwater test, presumably nuclear, with a yield of 1 KT. In the aggregate, the evidence substantiates an allocation of fissionable material to naval missions.

PATTERN OF SOVIET MILITARY ESTABLISHMENT

215. We continue to believe that—in line with our basic estimates of Soviet military policy, including the concurrent development of many types of forces and capabilities—the principal components of the Soviet armed forces undoubtedly have submitted requirements for nuclear weapons to carry out their various missions. Available evidence indicates that the Soviet leaders would not be likely to allocate all of the Soviet nuclear weapons stockpile to any one of these components to the exclusion of the others. Therefore, we estimate that, to the extent that the USSR continues to maintain a sizeable military establishment with extensive ground, naval, and air components, available nuclear weapons will be stockpiled for use by each of the major components.

DELIVERY SYSTEM ESTIMATES

216. The varying levels of confidence in our estimates of future Soviet strength in delivery systems requiring nuclear weapons have an important bearing on our estimates of possible stockpiles. This is especially true of long-range aviation and guided missiles, since for the latter our estimates presently cover only dates of development and *potential* production totals, so that we are forced to rely on assumptions only.

TARGET STUDIES

217. In preparing this estimate, we have entered into target studies directed in particular to targets related to US nuclear delivery capabilities. The selection of these targets is not, in most cases, difficult. However, many and complex variables—including estimates of US operational capabilities obtained from non-intelligence sources—are involved in estimating from the Soviet standpoint the number and yield of nuclear weapons in stockpile required to attain, under estimated attack conditions, certain probable damage levels on particular targets. Accordingly, we recognize that our target studies are subject to substantial margins of error in judgment, as well as to the effect of changes in US capabilities.

TECHNICAL FACTORS

218. Finally, account must be taken of the character of Soviet weapons in relation to the estimated amounts of fissionable material available.

219. A second technical factor is that of possible production rates for new designs and the rate of retrofit. In general, we have estimated that it would require 12–18 months for the Soviets to achieve quantity production of a weapons type once successfully tested. If the production model were an almost complete replica of the tested device, the period might be slightly less—and conversely longer if much adaptation were required. This factor has required special attention in the case of the mid-1959 illustrative stockpiles, in that the Soviet test series of the fall of 1958 did involve a number of tests which we believe the Soviets would wish to stockpile at an early date. In line with the above discussion, we have used only small quantities of such newer weapons for purposes of computing the mid-1959 illustrative stockpiles shown in Table 13.

ILLUSTRATIVE STOCKPILE ALLOCATIONS, MID-1959 AND MID-1962

Feasibility of Illustrative Allocations

220. In the light of the range and complexity of the factors discussed above, we do not believe it is possible or desirable to arrive at any single "most probable" estimate of the Soviet weapons stockpile at selected periods. It is possible, however, to arrive at certain "illustrative allocations"; and we believe that, as to certain missions, these allocations can properly be said to represent a reasonable maximum and minimum.

Assumptions of Soviet Military Policy for Illustrative Allocations

221. For the purposes of the illustrative allocations shown below, we have assumed two concepts of Soviet strategic emphasis at the reasonable extremes to which we believe either concept might be pressed in the period under review. The first, Alternative A, stresses those types of forces tending to increase Soviet capabilities for limited war while seeking to pre-

serve a deterrent to general war through long-range capabilities adequate to threaten the US with major damage.[29] The second, Alternative B, is based on dominant emphasis on long-range strike forces and is generally consistent with a military policy of preparing to fight, if necessary, a general war while seeking to deter its occurrence. The two alternative assumptions would affect particularly the number of high-yield weapons allocated to Soviet Long Range Aviation (LRA), and the allocation of low-yield weapons to air defense and tactical ground support. These categories appear as the major variables in our illustrative allocations.

General Caveat

222. In making these illustrative allocations, we have postulated totals of fissionable material for weapons purposes in line with the basic estimates shown in Table 10 on page —. If these totals were in fact in error within the possible margins stated in the estimate (e.g., ⅓ to twice the stated plutonium-equivalent values for mid-1959, and ±50% of the stated U–235 values for mid-1959, with greater uncertainties thereafter), then the totals shown in these illustrative allocations would of course be sharply affected. Moreover, the effect would be felt with greater acuteness in some of the subtotals than in others, partly because of the variation in unit requirements of fissionable materials, but more especially because of possible differences in strategy and basic allocation policy if greater or lesser amounts of fissionable materials were available. It is conceivable, for example, that if the amounts were only half those postulated for mid-1959, certain allocation categories might be reduced to nil. For this over-all reason, as well as for the reasons stated earlier, these illustrative allocations must be treated with great caution.

223. Considering the estimated availability of fissionable materials and the level of Soviet nuclear weapons technology, we believe that at present the USSR probably possesses sufficient nuclear weapons to support a major attack by its long range striking forces, including sufficient nuclear warheads for all of its operational submarine launched missiles and ground launched ballistic missiles of 700 n.m. range and greater. At present the quantity of fissionable material will limit the number of nuclear weapons available for air defense and tactical uses. This shortage will be considerably alleviated by 1962.

[29] The possibility of such a deterrent concept is discussed in paragraphs 99–101, of NIE 11–4–58, "Main Trends in Soviet Capabilities and Policies, 1958–1963," dated 23 December 1958.

IX. THE SOVIET INTERNATIONAL ATOMIC AID AND EXCHANGE PROGRAM

OBJECTIVES AND CAPABILITIES

232. The Soviet Union apparently has two objectives behind her offers of material and technical aid to other nations throughout the world. In making such offers to members of the Sino-Soviet Bloc, the objective is clearly to improve and tighten the relationships between the Soviet Union and her Satellites while at the same time maintaining a substantial degree of control of the atomic energy activities in these countries. In the offers to the Free World nations, the objective has been largely the propaganda impact that such offers are certain to produce. Offers to the underdeveloped nations have apparently been motivated by a desire to picture the Soviet Union as the great world leader and benefactor in the field of peaceful uses of atomic energy. Offers have been made to such "neutral" nations as Yugoslavia and Egypt as part of more general proposals of economic aid with the obvious intent of luring them into the Communist camp.

233. There is little doubt that the Soviet Union has the industrial, technical and economic capability to fulfill such offers of aid as have been made. The fissionable material required to meet the requirements of reactors completed, under construction, and promised to other nations of the world does not represent any significant drain on the existing

stockpiles of this material in the Soviet Union. Scientific personnel and laboratory facilities are available to give the technical training promised to scientists and technicians of both Bloc and non-Bloc nations.

CURRENT AND FUTURE AID TO BLOC COUNTRIES

234. Since as early as 1946, many of the Satellite nations have contributed extensively to the Soviet atomic energy program. Uranium ore was mined and shipped to the USSR as reparations payments from East Germany. Czechoslovakia, Poland, Rumania and Hungary shipped ore to the Soviet Union allegedly in gratitude for their "liberation." Actually the Soviet Union now pays these nations for the ore shipped, although strict supervision of mining, processing and shipment is maintained by the Soviets. Communist China has also supplied raw materials for the Soviet atomic energy program. Several of the Satellites have supplied significant quantities of instruments and equipment. [redacted]

235. Partly for purely political reasons, and partly to bind more closely a continuing source of uranium ore, instruments and equipment from the Satellites to the Soviet Union, the Soviets announced in 1955 an agreement under which they promised limited technical aid including a research reactor, cyclotron, radioisotopes and technical training to China and each of the European Satellites except Albania. The USSR has largely fulfilled these promises, although some of the Satellites have become impatient with Soviet delays and have objected to the high prices charged for Soviet equipment. Research reactors having a thermal capacity of 2000 kilowatts are now in operation in Rumania, Czechoslovakia, East Germany and Poland. Communist China has in operation a tank-type reactor with a thermal capacity of 7 to 10,000 kilowatts. In addition, they also have a 2 MW tank-type reactor in operation. Research reactors of the 2000 kilowatt (thermal) capacity are due to go into operation in 1959 or 1960 in Hungary and Bulgaria. In addition to the reactors and cyclotrons and radioisotopes furnished to the Satellites, basic technical training has been given to a limited number of Satellite scientists at laboratories and universities within the Soviet Union and at home from visiting Soviet scientists. However, steps have been taken to insure that advanced nuclear research would take place in the Soviet Union, where Satellite scientists would be subject to more effective control.

236. Reluctantly, Soviet aid has been promised to several of the Satellite countries in the construction of additional reactors. A 70 MW (electrical) reactor is already under construction in East Germany and completion is expected by 1961. Czechoslovakia is scheduled to start construction of a 150 MW (electrical) power reactor in the second half of 1958 with completion planned by 1963. Poland has been promised aid in the construction of an additional research reactor and in the construction of a power reactor. The power reactor has been tentatively planned for completion in 1965–70. Hungary has also been promised aid in the construction of a power reactor. There are indications that Communist China will be provided with two power reactors during the Chinese Second Five-Year Plan (1958–1962). Soviet controls over these power reactor programs include retention of Satellite dependence on Soviet isotope separation and spent fuel element processing facilities.

CURRENT AND FUTURE AID TO NON-BLOC COUNTRIES

237. To date, the only significant offers of aid to non-Bloc nations have been those made to Yugoslavia and Egypt. While these offers were originally made in 1956, neither nation can yet point to an operating reactor resulting from this Soviet aid. The reactor under construction in Yugoslavia is similar in type and capacity to that built in Communist China. The Egyptian reactor is to be of the same type and size as those to be found in the European Satellites.

238. The past two years have seen a significant decline in the number and extent of Soviet offers of atomic aid to nations in the Free World. The Soviet-proposed General Regional Body for Peaceful Uses of Atomic Energy, which was to include all the East and West European countries and the United States, has not materialized. The organization was probably proposed to disrupt the negotiations which were being carried out in the formation of EURATOM. When EURATOM was successfully organized and the Western nations refused to enter into the Soviet-proposed group, no further attempt by the Soviets to foster such a plan was made. Soviet overtures to Japan for a bilateral agreement as noted in 1956 were not followed up.

239. A large number of the offers made during the past year have been made to countries in the Asian area. An offer to present a peaceful uses of atomic energy exhibit was made to and accepted by Indonesia. Similar offers were made to Burma, Iran and India. In March 1958, the Soviets offered to exchange "know how" in the development of peaceful uses of atomic energy with countries of Asia and the Far East. They further suggested the establishment of a body within the Economic Commission for Asia and the Far East to study the economic factors and facilitate the exchange of information on this subject.

240. A slight interest in the South American area was noted in an interview between Brazilian newspapermen and Khrushchev in November 1957. In this interview, Khrushchev pronounced Soviet readiness to collaborate with Brazil in the atomic energy field through bilateral accord as well as the International Atomic Energy Agency. In early 1958, the Soviets, through the UN, supplied the University of Chile with instruments for the Laboratory of Nuclear Physics.

241. There is no evidence that the Soviets are attempting or soon will attempt to compete in the Free World for agreements to build research reactors. The offers are vague, such agreements as are completed are generally limited to basic technology, and implementation of the agreements is slow. It can be expected that in individual cases bilateral-type agreements will be signed similar to those in Yugoslavia and Egypt, but there is no evidence of a widespread program approaching that conducted by the US or the UK.

JOINT INSTITUTE FOR NUCLEAR RESEARCH, DUBNA

242. The Joint Institute for Nuclear Research (JINR), Dubna, USSR, was organized by the Soviets in March 1956 to encourage "collaboration between scientists of different countries in theoretical and experimental research in the field of nuclear physics in order to widen the possibilities of the use of atomic energy for peaceful purposes."

243. Much research has been conducted at JINR using the 680 Mev synchrocyclotron and the 10 Bev proton synchrotron. This research has been comparable in techniques and results to that of Western countries but has been somewhat lacking in originality. The research has little application to the nuclear power program for which the Satellites require trained scientists.

244. Additional research facilities being planned for JINR include an experimental high-flux reactor and a cyclotron for accelerating multiple-charged ions. This equipment is under construction but probably will not be completed for several years.

THE INTERNATIONAL ATOMIC ENERGY AGENCY

245. To date, the Soviets have co-operated in the workings of the International Atomic Energy Agency, although their attitude toward the Agency might best be described as passive. They have offered scholarships through the Agency and have made at least a token offer of fissionable material. Yemal'yanov, the Soviet member on the Board of Governors, has stated privately that he is not satisfied with the operations of the Board and that he feels that too many politicians rather than scientists have positions of responsibility in the organization. There has been further criticism of the lack of a firm program for the Agency.

246. To date, the Soviets have offered to supply the Agency with only 50 Kg of U–235 and have announced the availability of 40 to 50 scholarships for study of peaceful uses of atomic energy in the USSR. However, none of the Soviet institutes offered for IAEA training have had a significant role, if any, in the Soviet atomic energy program.

247. There are no indications that the Soviet Union intends to drop out of the IAEA, but it is believed that any significant Soviet aid to underdeveloped nations will be carried out through bilateral agreements rather than through any Agency program.

PARTICIPATION IN INTERNATIONAL CONFERENCES

248. Through participation in international conferences, the USSR has carried out agressive information collection and propaganda programs, reaching a peak during 1958 at the Second International Conference on the Peaceful Uses of Atomic Energy held in Geneva in September 1958. It is also apparent that the USSR rapidly integrates US results into the Soviet program. Intelligence reports, as well as evaluation of Soviet tactics at international conferences, indicate that the USSR carries out a well-organized, comprehensive and intensive information collection program through their participation in these conferences aimed at acquiring all available unclassified information as well as industrial confidential technology and classified information from the West, in many cases directed toward solving specific technological problems they have encountered in their own work.

249. The USSR has attempted to set forth one or all of three main propaganda theories at international scientific conferences related to atomic energy both at the conferences and in propaganda broadcasts for domestic as well as foreign consumption:

a. That "The Atom Must Serve Only the Cause of Peace," and the USSR is the prime mover in this effort;

b. That a primary goal of the conference is to open up "possibilities for the cooperation of scientists and the exchange of the latest knowledge and experience between countries in the sphere of atomic science and technology," and the USSR has expended "great efforts in promoting wide international cooperation in peaceful uses of atomic energy"; and,

c. That the USSR, as with Sputniks, is first in atomic energy, primarily in controlled thermonuclear reactions and nuclear power reactors.

X. ECONOMIC ASPECTS OF THE SOVIET NUCLEAR ENERGY PROGRAM [32]

ECONOMIC CONSIDERATIONS

250. It seems probable that Soviet officials were willing to accept high-cost methods of plant design and operation during the earlier phases of their nuclear energy program in the interests of achieving an assured fissionable materials production more quickly.

251. However, intelligence strongly suggests that economic considerations exerted progressively greater influences in the operation of uranium ore, metal, and enriched U–235 production facilities throughout the 1950–1958 period.

252. We estimate that Soviet officials, within the limits of assigned production goals, have accorded great—if not predominant—weight to economic considerations, since at least 1954, in the selection of operating procedures on the basis of which production directives were carried out. This is to say, we feel that the managers of the Soviet program after 1954 attempted to an even greater extent to achieve the assigned output of fissionable materials with the least possible expenditure of economic resources; in contrast to the earlier policy of an assured production in the shortest possible period. We feel, further, that within the near future, the determination of the size of fissionable materials production will not

[32] The Assistant Chief of Naval Operations for Intelligence, Department of the Navy, does not concur in the economic section because it is based upon a method of cost analysis that he does not consider can be applied to the USSR fissionable materials estimate.

be immune to economic considerations, if indeed they are completely so at the present time.

253. However, our present estimates of uranium feed procurement and fissionable materials output are inconsistent with the most economic use of Soviet resources. We have estimated that, through 1959, the Soviets fed to diffusion plants and reactors only about two-thirds of the uranium they procured and realized less than one kilogram of product (U–235 and Pu) for each ton of uranium fed. The Soviets have had strong economic incentives to use their above-ground uranium resources much more intensively, at least since 1953. If the Soviets had the plant capacity to strip the economically recoverable product from substantially all of their above-ground ore, potential production of fissionable materials would have been about four times the present estimated total. The production facilities for which we have evidence, however, would have produced no more than twice the output estimated here, even at the upper limits of estimated size and efficiency. Our most probable estimate of actual production is based on evidence that suggests that plant sizes and efficiencies were considerably less than the upper limits.

SIZE OF THE PROGRAM

254. We estimate that the approximate cumulative cost of the Soviet nuclear energy program through mid-1959 has been over 92 billion rubles of which about 41 billion were expended for plant and equipment and almost 52 billion rubles for operating purposes. These data are in terms of 1955 ruble values and were derived from cost studies of the estimated Soviet nuclear energy program. Table 15 shows the estimated cumulative values in terms of investment and operating expenditures by major functions. These and other cost estimates must be considered as first approximations and are subject to wide margins of error; however, it is felt that they adequately reflect general magnitudes and relations.

Table 15

FUNCTIONAL BREAKDOWN OF CUMULATIVE EXPENDITURES THROUGH MID-1959

Function	Millions of 1 July 1955 Rubles		
	Investment	Total Operating Expenditures [a]	Total Expenditure
Uranium Procurement and Ore Concentrating	7,700	16,800	24,500
Feed Materials	600	3,600	4,200
Plutonium Production	8,500	3,900	12,400
U–235 Production	12,500	4,800	17,300
Communal Facilities	2,750	..	2,750
Research and Development	3,650	8,000	11,650
Weapons	5,000	12,100	17,100
Administration and Miscellaneous	..	2,500	2,500
TOTAL	40,700	51,700	92,400

[a] Does not include amortization.

255. Omitting investment in uranium mining and ore concentrating, which are not included as such in reported US-AEC expenditures, we estimate that as of mid-1959 the Soviet program has spent approximately 85 billion 1955 rubles,[33] or less than 0.8% of the gross national product of the USSR for the same period. Similarly, estimated average annual expenditures during this period are 8.4% of total Soviet budget appropriations for heavy industry in 1956.

256. Table 16 compares investment in plant and equipment for the nuclear energy program with that of other priority programs. It should be borne in mind that the nuclear energy program had essentially no capital structure prior to 1948–1949, while the other industries which are herein considered were well established by that time, and each one was undergoing expansion with the greatest rapidity in order to permit a large and economy-wide increase in total industrial output of the country.

[33] For comparison purposes the US program during a comparable period has spent about 21 billion 1955 dollars.

Table 16

COMPARISON OF CAPITAL INVESTMENT IN NUCLEAR ENERGY TO THAT IN SELECTED INDUSTRIES, USSR

	Billions 1 July 1955 Rubles		
	1956	1957	1958
Nuclear Energy	3.8	4.1	4.1
Investment in National Economy	180.0	[a] 210.0	[a] 232.0
Total Industry	[a] 104.4	[a] 111.2	[a] 129.5
Chemical Industry	N.A.	4.7	7.2
Ferrous Metallurgy	8.7	8.8	[b] 12.1
Petroleum Industry	10.8	11.9	15.2
Electric Power	10.0	11.0	12.0

[a] Current Prices.

[b] Plan Figure.

FISSIONABLE MATERIALS COST

257. Costing studies indicate that a ratio of 5.5 rubles to one US dollar appears reasonable for converting nuclear energy investment cost in the USSR to the currency of the U.S. On this basis, total US expenditures for nuclear plant and equipment equaling 8.0 billion 1955 dollars equate to 44 billion 1955 rubles. The 44 billion ruble equivalent US expenditure is to be compared with an estimated Soviet nuclear investment of 33 billion 1955 rubles. In monetary terms, therefore, USSR nuclear investment is approximately three-quarters that of the U.S. However, the actual ratio of USSR to US production, based upon our current estimates of the Soviet program, is very much smaller. Due to generally lower levels of technological development and operating efficiencies, the Soviet program requires considerably more physical plant per unit of output. While a technological lag of such proportions is not currently evident in any other priority sector of the Soviet economy, we have intelligence which supports a relatively low efficiency.

258. A rough estimate of the cost of producing a gram of 90% enriched U–235 in the USSR is about 220 rubles during 1959. Based on published US charges for enriched uranium, the apparent ruble-dollar ratio for this commodity is, therefore, at least 14 rubles per US dollar. This high ratio is due to low estimated Soviet plant efficiencies and relatively high charges for USSR electric power. For example, it has been estimated that the Soviet diffusion plant at Verkhneyvinsk cost on the order of 6 billion rubles. If a plant of equal capacity were constructed in the US, it would have cost perhaps 400 million dollars. In terms of comparable capacities, therefore, a ratio of 15 rubles per US dollar is indicated. This value is more than twice that (5.5 rubles per US dollar) which appears reasonable for converting nuclear energy investment costs of one country in terms of currency of the other. In short, the difference is largely due to the greater physical plant required in the USSR to produce a unit of enriched U–235.

259. A gram of weapon grade plutonium is estimated to have cost 1,235 rubles in 1959 when no credit is allowed for the re-use of reactor tails. Allowing a credit for the value of the reactor tails, which are estimated to have been used for U–235 production in 1959, would reduce the cost of a gram of plutonium to 860 rubles in that year. The cost of 860 rubles per gram is about 20 times the published US dollar price for the purchase of plutonium produced in private power reactors. This high indicated ruble dollar ratio (20:1 as compared to 5.5:1 for the construction of plant) results from our estimate of Soviet failures to approximate US technological advances in plutonium production. Specifically, the failures are to approach a par with the US with respect to: 1) specific power levels for production reactors; 2) fuel irradiation levels and; 3) full utilization of reactor tailings as subsequent feed for gaseous diffusion plants.